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Systematics of the Genus *Augochlorella* (Hymenoptera, Halictidae) North of Mexico[1]

By

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ABSTRACT

In a revision of the bee genus *Augochlorella*, descriptions and keys are given for seven species occurring north of Mexico and one species and a subspecies from Mexico. One species from Texas, *A. bracteata* and the subspecies *A. neglectula maritima* from Mexico are new, and the male of *A. edentata* is described for the first time; *A. neglectula* is raised from synonymy, and *A. aurata* of recent authors has been divided so that most of the specimens from north of the Gulf Coast states are placed in *A. persimilis*. Other species treated are *A. pomoniella, A. gratiosa* and *A. striata*. Regional as well as individual variations are treated in detail since there is considerable morphological intergradation among females of some species.

INTRODUCTION

Although bees of the genus *Augochlorella* (Halictidae) are common over much of the United States, their interspecific relationships and biologies are little understood. This paper is a result of a study of interspecific relationships of the two species of *Augochlorella* occurring in the vicinity of Lawrence, Kansas. Females of the two species, *persimilis* and *striata*, could not be satisfactorially distinguished and preliminary biological observations indicated little or no difference between them. In order to understand the nature of the variations and intergradations occurring between these two, all species occurring within the United States were examined. They are redefined and illustrated, keys for their identification are provided, and variations within species analyzed.

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For those investigators who are interested chiefly in the species occurring in a certain area, primary use should be made of the Regional Account of the Species. Other sections to be consulted include the discussion of the genus, the section on terminology, the keys to the species and under the Species Accounts, parts on comparisons with other species and seasonal activity.

For those interested primarily in studies of variation, special attention should be given to sections on Specific and Other Characters, Terminology, Species Groups and under the Species Accounts, parts on comparisons and variation. The regional account should also be of value.

Augochlorella is a genus of bright metallic blue or green bees. As in most halictines, the species are morphologically variable and are in many cases difficult to distinguish. Therefore, special attention is given to the nature and extent of variations within and among species. Since other species, not being considered in this work, occur in Mexico, Central and South America, a complete analysis cannot be attempted until all species have been studied, preferably both biologically and morphologically. Eight species are treated here; seven occur north of Mexico, the other is from Mexico and Central America.

The more than 14,000 specimens examined in this study were obtained from a total of 50 private and institutional collections (Table 1). In addition to the pinned material, 414 specimens were examined from 134 nests excavated near Lawrence, Kansas, and the variation compared with that of populations throughout the country.

Table I. Collections studied.

Code No.	Collection
1	University of Arizona, Tucson.
2	University of Arkansas, Fayetteville.
3	California Academy of Sciences, San Francisco.
4	University of California, Berkeley.
5	Los Angeles County Museum, Los Angeles, California.
6	P. H. Timberlake Collection, Riverside, California.
7	University of Colorado Museum, Boulder.
8	Colorado State University, Ft. Collins.
9	United States National Museum, Washington, D.C.
10	State Department of Agriculture, Gainesville, Florida.
11	University of Georgia, Athens.
12	Fattig Collection, University of Georgia, Athens.
13	Chicago Natural History Museum, Chicago, Illinois.
14	Illinois Natural History Survey, Urbana.
15	Robertson Collection, Illinois Natural History Survey, Urbana.
16	Purdue University, Lafayette, Indiana.
17	Indiana University, Bloomington.
18	Iowa State University, Ames.
19	Kansas State University, Manhattan.
20	University of Kansas, Lawrence.

Code No.	Collection
21	Carl W. Rettenmeyer Collection, Kansas State University, Manhattan.
22	Museum of Comparative Zoology, Cambridge, Massachusetts.
23	University of Massachusetts, Amherst.
24	R. R. Dreisbach Collection, Michigan State University, East Lansing.
25	Michigan State University, East Lansing.
26	University of Minnesota, St. Paul.
27	University of Missouri, Columbia.
28	University of Nebraska, Lincoln.
29	David W. Ribble Collection, University of Nebraska, Lincoln.
30	Rutgers, The State University, New Brunswick, New Jersey.
31	Cornell University, Ithaca, New York.
32	American Museum of Natural History, New York City, New York.
33	North Carolina State, Raleigh.
34	North Dakota Agricultural College, Fargo.
35	University of North Dakota, Grand Forks.
36	Ohio State University, Columbus.
37	Oklahoma State University, Stillwater.
38	Academy of Natural Sciences of Philadelphia, Philadelphia, Pennsylvania.
39	Carnegie Museum, Pittsburgh, Pennsylvania.
40	South Dakota State College, Brookings.
41	University of Tennessee, Knoxville.
42	Alvin F. Shinn Collection, Oak Ridge, Tennessee.
43	Utah State University, Logan.
44	George E. Bohart Collection, Utah State University, Logan.
45	Brigham Young University, Provo, Utah.
46	Milwaukee Public Museum, Milwaukee, Wisconsin.
47	University of Wisconsin, Madison.
48	British Museum (Natural History), London.
49	Canadian National Collection, Ottawa.
50	Naturhistorisches Museum, Wien, Austria.

The genus *Augochlorella* was proposed (with the type species *Augochlora gratiosa* Smith) by Sandhouse (1937) in a revision of an assemblage of forms that had previously been included in the genus *Augochlora*. Prior to the revision by Sandhouse, all green halictines except *Agapostemon* were commonly referred to *Augochlora*, including forms now placed in *Augochlora*, *Augochloropsis* and *Augochlorella*. [For synonymies of these genera, see Sandhouse *(op. cit.).*] I am not certain of the status of *Pereirapis* Moure, which was synonymized with *Augochlorella* by Michener (1954). Since the species included in *Pereirapis*, except for *edentata* (see Species Groups), are distinctly different from those of the north and are separated from each other by entirely different characters, I feel that they form a legitimate group which should perhaps be recognized at the subgeneric level.

Moure (personal communication, 1961) has included the following species in the *Pereirapis* group: *A. bidentata* Michener, *A. cerasis* (Vachal), *A. chrysaspis* (Vachal), *A. edentata* Michener, *A. phoenicis* (Vachal), *A.*

semiauratus (Spinola) [=*A. titania* (Smith), *A. hypixis* (Vachal)], *A. seminigra* (Cockerell) (=*P. rhysophila* Moure) and *A. simotes* (Vachal). He has also indicated that the following Central and South American species are to be placed in *Augochlorella* proper: *A. cladopyga* (Cockerell), *A. comis* (Vachal), *A. ephyra* (Schrottky) [=*A. traumatias* (Vachal), *A. ictis* (Vachal) and *Oxystoglossidia uraniella* Moure], *A. iopoecila* Moure, *A. iphigenia* (Holmberg), *A. michaelis* (Vachal) (=*Oxystoglossidia uranioides* Moure), *A. tredecim* (Vachal), *A. urania* (Smith).

Some Diagnostic Characters

The genus can be distinguished from the other genera of green halictines occurring north of Mexico by the key below. A detailed description was given by Sandhouse (1937) and modified by Michener (1954). The following account, therefore, is brief and presents only the most diagnostic and readily visible characters by which *Augochlorella* can be distinguished from the other nearctic halictines of similar appearance.

HEAD: *The epistomal suture* (Fig. 2, *es.*) in *Augochlorella* and *Augochloropsis* extends ventrolaterally on each side of the clypeus to the level of the mandibular base where it angles abruptly laterally. In *Augochlora* and most *Agapostemon* it loops below the level of the mandibular base into the clypeal area, thus forming a lobate extension of the paraocular area (Fig. 1).

The *clypeus* is flattened in *Augochlorella* but with the apical half beveled or at a slight angle to the upper half. Females have the beveled portion brown or black with large, coarse, well separated punctures. The upper half is metallic green or blue with smaller punctures of varying sizes. In *Augochlora* the clypeus is flat, or the beveling is not noticeable since the entire surface is green except for a narrowly black apical edge. In *Augochloropsis* the clypeus is protuberant and rounded, sometimes slightly darkened medially at the apex. The clypeus of *Agapostemon* is similar to that of *Augochlorella* except for the ventrolateral or lobate extensions of the epistomal suture.

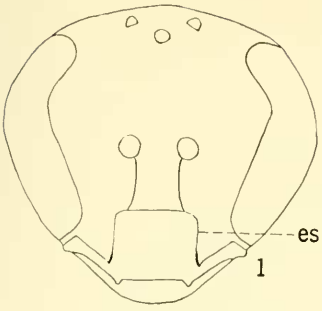
The vertex in *Augochlorella* is short, about equal to the oculo-ocellar distance, and abruptly angled or declivous between the posterior ocelli and the occipital carina (Fig. 5). In *Augochlora* this area is broadly rounded and longer than the oculo-ocellar distance (Fig. 3). In *Augochloropsis* the vertex is long and sharply angled so that the occipital carina is usually hidden from

Figs. 1-2. Front view of head. Fig. 1, *Augochlora*; Fig. 2, *Augochlorella*; *es:* epistomal suture.

Figs. 3-5. Side view of head. Fig. 3, *Augochlora*; Fig. 4, *Augochloropsis*; Fig. 5, *Augochlorella.*

Figs. 6-9. Forewings. Fig. 6, *Augochlorella*; Fig. 7, *Augochlora*; Fig. 8, *Augochloropsis*; Fig. 9, *Agapostemon.*

Figs. 10-11. Body measurements. Fig. 10, a, width of head; b, length of clypeus; c, width of clypeus; Fig. 11, a, length of metanotum; b, length of propodeum.



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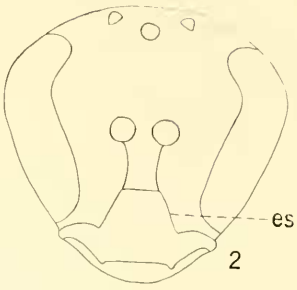

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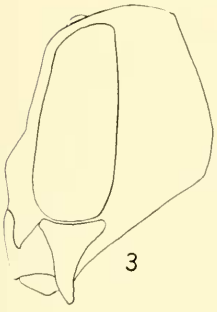

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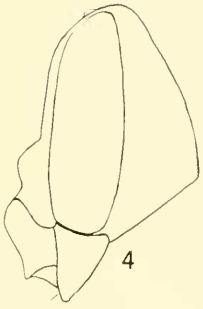

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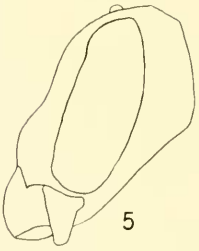

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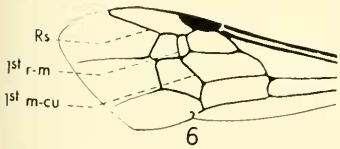

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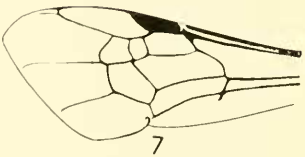

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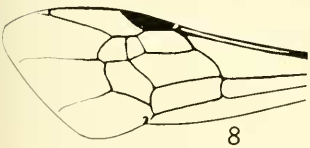

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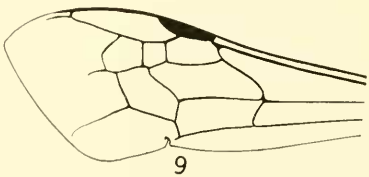

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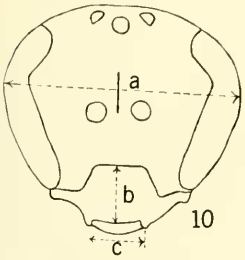

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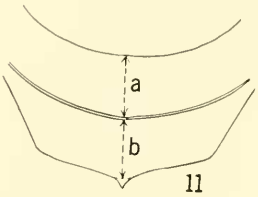

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above except when the head is strongly depressed (Fig. 4). In *Agapostemon* the vertex is similar to that of *Augochlorella*.

THORAX: The posterior vertical surface of the propodeum of *Agapostemon* may be distinguished from that of all the other genera by the key character given below.

The marginal cell of the forewing in *Augochlorella* is pointed at the wing margin (Fig. 6), whereas in the other three genera it is narrowly truncate at the tip or bent away from the margin of the wing. In *Augochlora* and some *Agapostemon* and *Augochloropsis* the lower vein of the marginal cell (*Rs*, Fig. 7) extends beyond the tip of the cell.

KEY TO GENERA OF GREEN HALICTINES OF THE UNITED STATES

1. Body surface strongly sclerotized with large, deep punctures, similar to that of chrysidids; female without scopa ..... *Temnosoma*
— Body surface not as above; females with scopa on hind legs 2
2. Posterior vertical surface of propodeum enclosed by a strong carina; first recurrent vein (1st m-cu) basad of 1st r-m (Fig. 8) ..... *Agapostemon*
— Posterior vertical face of propodeum not enclosed by a carina; first recurrent vein interstitial with 1st r-m (Fig. 6) 3
3. Epistomal suture forming deep loop into clypeal area, extending below level of base of mandible (Fig. 1) ..... *Augochlora*
— Epistomal suture forming right angle, bending laterally at level of mandibular base (Fig. 2) 4
4. Marginal cell pointed on margin of wing (Fig. 6); inner hind tibial spur of female serrate; metasomal terga without fringe of long apical hair ..... *Augochlorella*
— Marginal cell either truncate and appendiculate apically or pointed below margin of wing (Fig. 9); inner hind tibial spur of female pectinate 5
5. Tegula with inner posterior angle lobate; pronotum with dorsal edge carinate or lamellate; apical margins of metasomal terga green, usually with fringe of simple, apical hairs ..... *Augochloropsis*
— Tegula oblong, not lobate posteriorly; pronotum with dorsal edge rounded or angulate; apical margins of metasomal terga black, without fringe of apical hairs ..... *Pseudaugochloropsis*

TERMINOLOGY

Terminology for all morphological structures follows that of Michener (1944) unless otherwise stated. In the interests of simplicity and conservation of space, certain terms have been used in the descriptions and discussions of variation which may seem vague; they have been used, however, in precise ways as explained below:

The body *surface*: the integument of a sclerite in general or the areas between punctures, striations or other specifically mentioned conformations when present; its degree of shininess and roughening are often significant characters.

Shininess: *polished*, absolutely smooth at magnifications used and highly reflective; *shiny*, reflective but not brilliant and not necessarily smooth; *dull*, not shining although sometimes appearing smooth at magnifications used.

Roughness: *smooth*, without obvious irregularities or unevenness; *granular*, with very small, round pits, usually regularly distributed, giving the illusion of raised bumps as on fine sand paper; *rough* or roughened, with a slightly irregular or uneven surface but without any obvious pattern to the unevenness; *rugose*, deeply roughened or wrinkled, often forming a regular pattern with the elevations and ridges occupying an area as large as or larger than the depressions; *areolate*, deeply rugose, forming a network of ridges with depressions occupying greater areas than the elevations or ridges.

The degree of roughening or punctation is described by the following adverbs in sequence starting with the least amount of roughening: *minutely*, *weakly*, *finely* and *coarsely*. An adjective when used by itself (i.e., "rough") describes a condition between fine and coarse.

Punctures distinct: This expression is used if each puncture is separated from every other puncture, with the outlines easily discernible. Punctures may be very close together but nevertheless easily recognizable as individual punctures.

Punctures indistinct: This expression is used if the punctures are not easily recognizable as distinct entities and may be either shallow or minute and vaguely defined or may merge together.

Disc refers to the dorsal area of the propodeum only. *The edge of the disc* refers to the angle formed between the dorsal and posterior surfaces of the propodeum. It grades from sharp or weakly carinate to gradually rounded. The *shape* or *outline of the disc* is the pattern formed by the edge of the disc when viewed from above.

Form refers only to particular variants in the species *striata*.

METHODS

Equipment. All specimens were examined under 40× magnification of a dissecting microscope. A 100 watt incandescent bulb was used when recording body sculpturing. A microscope light with blue filter was used to view the color of body and pubescence.

All photographs were taken at the same magnification and those appearing in any one plate are reproduced at the same magnification.

Measurements were made by means of an ocular micrometer at 40×

magnification. In all cases, the specimen was aligned so that both extremities of the structure being measured were in focus and a maximum measurement obtained of the distance between them.

Synonymies. In the synonymy of each species all known references are given, with annotations indicating the content as follows: descriptions or descriptive comparisons with other species (descr.), distributional records (distr.), flower records (fl.), keys (key), annotated or unannotated lists of species such as catalogues or regional compendia (list), and taxonomic treatments usually including keys, distributions, descriptions, etc. (tax.). Secondary references to synonymies in catalogues or taxonomic treatments are not included. Certain authors (Rau, 1922) have confused species of *Augochlorella* with *Augochlora pura*. References published under specific names of *Augochlorella* (e.g., *striata*) but known to refer to *Augochlora pura* are of course omitted from the synonymies.

Types. The type (holotype or lectotype) has been seen for each species unless otherwise noted.

Descriptions. With the exception of *persimilis* and *striata*, all specimens of a species were examined for all characters. During the course of the study all but those characters finally used in the descriptions were eliminated, usually because they were found to have little or no diagnostic value. The genitalia of about 50% of the males of each species, from localities throughout the range, were examined.

Because of the large number of specimens of *striata* and *persimilis*, the descriptions and detailed examinations of these species were made from a sample of about 50 specimens, mostly from one state. Samples from all other states were then compared with the description, and corrections and variations noted. Every specimen in both species, both male and female, was critically examined with regard to all propodeal characters and metasomal punctures and for the basitarsal hair of males. Other characters received attention commensurate with their diagnostic value. For variable characters in *persimilis*, enough specimens were examined to determine the extent of the variation and the distribution of the variants. For *striata*, variation was studied by recognizing several lettered "forms." The details are indicated in the discussion of that species.

Variations. An attempt has been made to indicate as closely as possible the range of variation of each character in each species. Whenever practical, particular specimens have been cited to illustrate certain variational features, or percentages are given if large numbers of individuals are involved. Particular specimens are identified by their label data followed by the code numbers, in parentheses, of the collections in which they are located (see Table 1).

In the section on regional variation all species occurring within each geographical area are compared.

Although much attention has been paid to the problem of variation in this group, this is not primarily a study of variation and at least in one species, *striata*, a considerable amount of work, both analytical and statistical, still needs to be done before a complete understanding can be achieved.

Distributions. Although a complete list of all label data has been made, and may be obtained from the author, localities are listed in this paper only by counties and are indicated on maps. Specific localities are given where the counties are large with widely varying habitats. Only those specimens that have been examined are recorded (unless otherwise specified). Records from the literature are omitted due to the unreliability of specific determinations.

For economy of space, listing of localities is omitted in whole or in part for certain common eastern species. Localities are shown approximately by the maps, and counties are listed by Ordway (1965).

Seasonal Activity. The data on this topic were obtained from pinned material unless otherwise noted. Dates given for seasonal activity are those on which collections were made and do not necessarily represent the entire season of the bees' activity.

Flower Records. Flower records were taken from the literature and from labels on pinned specimens but not from laboratory observations since host plant preferences in the laboratory are shown to have little correlation with those in the field under natural conditions (see Ordway, in press). The records listed under each species show the flowers on which bees were found without regard to the sex of the bee or to whether the bee was collecting pollen or nectar, since this information is usually not available. All flower names have been checked and the appropriate synonymies made according to the following references: Fernald (1950), Gould and Thomas (1962), Kearney and Peebles (1951), Munz (1959), Smith (1933) and Index Kewensis (1895-1955).

SPECIFIC CHARACTERS

Nearly all of the specific characters vary in a continuous manner, so that it is difficult to categorize the differences within and among species. Many of the characters are self explanatory but others require explanation and are discussed below. Some of these characters are of no value in distinguishing the North American species from one another but are of value in distinguishing certain neotropical species.

Body color. Coloration throughout the range of the species is extremely variable. The usual color is a bright green, but specimens may range from bronzy or yellowish green to a deep violet-blue. Blue specimens are found only in Florida. The part of the body with the greatest color variation is the metasoma where coloration is often incomplete, allowing various amounts of

brown to show through, so that in some specimens this area looks brown with metallic reflections. Of the species considered in this paper, only the males of *edentata* have the metasoma consistently and naturally brown. It was found that in dried specimens, normally testaceous color (pale yellow-white) structures may in some specimens turn orange due to ageing or other factors. This condition has not been found in live or freshly killed bees.

The metallic color is structural and can be altered artificially by various environmental conditions or chemicals. Limited tests have shown that dried bright green bees turn blue-green to blue within five minutes in ethyl acetate (liquid) and that on drying, the bees stay blue-green. If they are then put into water the bright green color slowly returns. Bees preserved in alcohol or in Dietrich's or Carnoy's solutions remain green, but dry, bright green or yellow-green bees turn coppery-green to reddish in an atmosphere containing phenol (as in a relaxing chamber). Depending on the concentration and exposure time, the altered color may remain after the specimen has redried.

Chemicals may affect the coloration of insects found in collections. The color of live bees may be determined or influenced during the pupal stage by atmospheric or soil moisture. Specimens of *Augochlorella* found in Florida are uniformly darker green than they are to the north but it is not known whether the bright blue individuals, frequently found in collections from Florida, actually are this color in nature. Many of the blue specimens were collected by Graenicher. It is possible that he and some other collectors in Florida used acetate killing jars, thus changing the color of the bees. Some *persimilis* were reared in the laboratory in wet soil. Emerging females were usually a dark green but one blue individual was produced. The males produced were mostly the yellow-green color typical of both sexes of this species in Kansas. The blue reflections found on the frontal area of the head in some species appear to be a natural phenomenon with variation only in the intensity.

Size. Total body length, although inexact, gives a rough indication of the overall length and is given for comparison with species described by earlier workers. When a wide variation of lengths occurs the extremes are given. All measurements are made on individuals with bodies in extended positions. Width of the head is a more standard and reproducable measurement and has been shown (Michener and Lange, 1958), at least for *Lasioglossum rhytidophorum*, to be highly correlated with other body measurements such as wing length and thoracic size. Both in *A. striata* and *persimilis* a high correlation (r values significant at $< .01$) was also found between the width of the head and length of the wing with r values of .65 and .55 in *striata* and *persimilis* respectively (see Ordway, in press, a, for full discussion of variation). Head width was measured across the widest part of the face, at about the level of the ocular emargination (Fig. 10a). When available, at least 50

males and 100 females of each species were measured from throughout its geographic range, representing as wide a span of collecting dates as possible. An effort was made to include all size extremes. In *striata*, all "forms" were lumped together. Wing length was not used, as it is a difficult and unreliable measurement on dried material. The width-to-length relationship of the head is given as an indication of the shape of the face. Bees in which the length of the head is greater than the width have a face that appears long (Fig. 52); when the length is equal to the width (± 0.4 mm), it appears round (Fig. 53), and when the width is greater than the length, the face appears wide (Fig. 54). In some species the shape of the face is relatively constant; in others it is variable. The length of the face was measured from the apex of the clypeus to the vertex, with the head positioned so as to give a maximum measurement and with the distance being determined when both extremities were in focus. It is a poor measurement to use by itself, as it is frequently inexact or cannot be reproduced exactly on the same specimen. However, as a comparison with the width (greater than, equal to or less than), it is quite usable, and the same proportions may be obtained after multiple readings.

Clypeus. The clypeus in all species studied is largely green or similar in color to the rest of the head. In males, the apex is narrowly testaceous medially, slightly more extensively so at the lateral corners. In females the apex of the clypeus is nonmetallic brown or black, the extent of the nonmetallic area being variable within and among species. The length (Fig. 10b) is usually equal to or slightly greater than the width (Fig. 10c) in both sexes. The size and spacing of the punctures on the clypeus usually varies within species although some species have a more uniform pattern than others.

Supraclypeal area. This area is slightly convex and looks protuberant in all species except *edentata*. This protuberance is due more to depression of the epistomal suture and antennal sockets than to an elevation of the area itself. In *edentata* and some other neotropical species, there are scarcely any depressed areas so that the entire face looks broadly and evenly convex.

Tegula. The length to width ratio of the tegula differs among species. In all species unless otherwise noted, this structure is oval, shiny and smooth, transparent to pale yellowish anteriorly, becoming darker posteriorly and dark brown, usually with metallic reflections, along the proximal edge. The anterior part is usually minutely pilose.

Propodeum. The characters of the propodeum are highly variable. All variation is more or less continuous so that there are rarely distinct gaps separating species, and yet these characters are still the most diagnostic for distinguishing species, especially in the females. The length of the disc (the dorsal area) is measured along the median line from the anterior carina separating the metanotum and propodeum, to the posterior margin of the

disc. When the posterior margin forms a sharp V medially, the posterior edge is assumed to be evenly rounded and the tip of the V is omitted from the measurement (Fig. 11b).

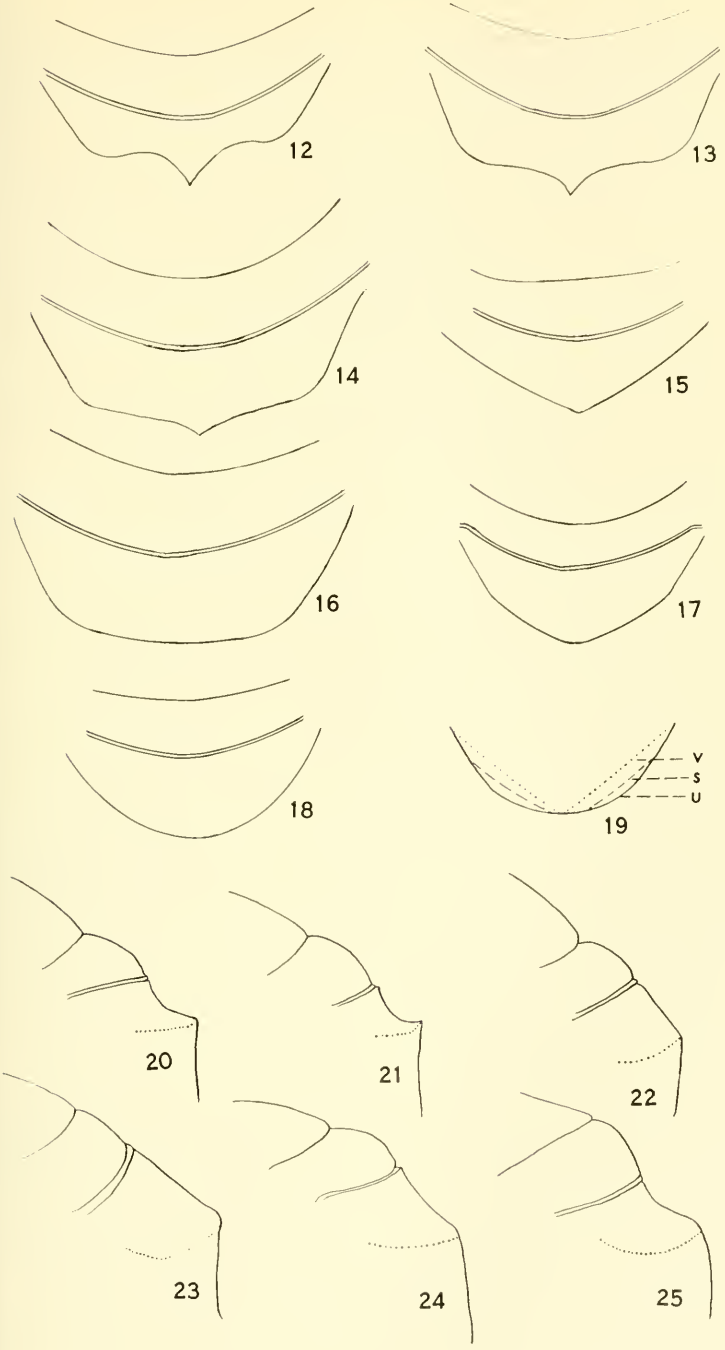
The outline or shape of the disc is classified into four categories, although all gradations occur among these. The "bracket" shape (⌈) is perhaps the most distinctive (Figs. 12-14, 57, 58) and is characteristic of *gratiosa*, *aurata* and some *striata*. The posterior edge comes to a point or V medially, slopes laterally to the posterolateral corners of the propodeum, then angles abruptly anterolaterally. The V-shape is similar but without the distinctive angulation at the posterolateral corners. The V may be deep, so that the length of the disc is considerably longer medially than at any other point, as in some *striata* B (Figs. 15, 63), or it may be shallow or "obtuse" with the length of the disc essentially equal throughout (Fig. 59). In addition, the posterior edge may be sharply pointed medially (Fig. 12) or blunt and rounded (Fig. 14), or may extend posteriorly in the plane of the rest of the disc or be depressed onto the posterior vertical propodeal surface (Fig. 63). The U-shape (Figs. 16, 62) lacks the medial V and is evenly rounded posteriorly. The length of the disc is greater medially than laterally. The semicircular shape is similar to the U-shape but is shorter in relation to its width, with shorter, more rounded posterolateral corners (Figs. 18, 64). Gradations among all shapes occur (Figs. 17, 65). Relationships of the different shapes are diagrammed in Figure 19.

The sharpness of the edge and the flatness of the disc is indicated by the profile type. In type 1 (Figs. 20, 21), the edge of the disc is weakly or sharply angulate to carinate and slightly elevated, giving the disc a concave appearance in profile. In type 2 (Fig. 22), the edge is abruptly rounded, not elevated, and distinct when viewed from the top. The surface of the disc is flat. In type 3 (Fig. 23), the edge is rounded but slightly prominent or thickened, so that although the edge is definite when viewed from above it is not as distinct as in type 2. Type 4 has a gradually and smoothly rounded edge (Fig. 24) without any demarcation between the dorsal and vertical surfaces. Type 5 (Fig. 25) includes only *pomoniella* and combines characteristics of types 3 and 4. The edge of the disc, although gradually and smoothly rounded, is at the same time prominent and somewhat elevated. The dorsal surface of the disc is therefore slightly concave, a feature that is evident both from the top and from the side.

Figs. 12-18. Diagrams showing shapes of propodeal disc. Figs. 12-14, bracket-shaped; Fig. 12, *A. gratiosa*; Fig. 13, *striata* A; Fig. 14, aurata. Fig. 15, V-shaped, *striata* D. Fig. 16, U-shaped, *pomoniella*; Fig. 17, U-shaped, *edentata*. Fig. 18, semicircular, *bracteata*.

Fig. 19. Relationship of disc shapes: v, V-shaped; s, semicircular; u, U-shaped.

Figs. 20-25. Diagrams showing profiles of thorax. Fig. 20, *A. striata* A, type 1; Fig. 21, *gratiosa*, type 1; Fig. 22, *aurata*, *persimilis*, *bracteata*, type 2; Fig. 23, *striata* B, D, *neglectula*, type 3; Fig. 24, *striata* C, *edentata*, type 4; Fig. 25, *pomoniella*, type 5.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When the striae do not reach the posterior edge of the disc or the edge is unclear as in profile type 4, the surface of the disc beyond the striae may be variously marked with granulations (Fig. 62), fine ridges (Fig. 66) or minute transverse lines or reticulations (Figs. 67, 69, 70); each type of surface is characteristic of certain species.

The posterior vertical surface of the propodeum is also variously sculptured in the different species, grading from smooth and shiny with minute punctures (Fig. 73) to smoothly granular (Fig. 74) to roughened and rugose (Fig. 75). There is some variation within species, particularly among the forms of *striata*, but in general each species is characterized by a certain type of sculpturing.

Metasoma. Because the first abdominal segment is incorporated into the thorax, segments of the apparent abdomen are numbered from one on and are called metasomal segments. Numbered terga and sterna always refer to these metasomal segments.

The size and density of punctures on the first and second tergum are variable within and among species in both males and females, sometimes varying geographically. The punctures may be distinct and regular or they may be indistinct, irregular or variable in size and spacing. The third and following terga in all species studied are densely and minutely punctured, with the punctures inconspicuous and blending together giving the surfaces of the terga a minutely reticulate appearance. The apices of the terga are narrowly margined with brown in all species. The sterna of both males and females are brown, with long hair on at least the apical halves. In females this hair is longer than in males and is frequently used by the bee as part of the scopa. In addition to color variations noted in a previous paragraph, the first and second terga may show dull, discolored areas on the dorsal median surface. This is due to a waxlike secretion from this area (Fig. 56) that leaves the otherwise shiny surface dull. The nature and function of this secretion is not known, but it occurs only in females of all species of *Augochlora* and *Augochlorella* examined. It is not found on fresh, young (entirely unworn) specimens but the discoloration, if not the waxlike substance itself, may be found on most older specimens.

Pubescence. Over most of the dorsal part of the body there are two types of pubescence, the long, simple or branched hairs usually referred to as the pubescence or hairs and exceedingly short, fine, highly plumose pubescence

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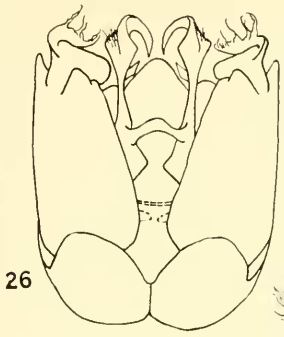
Figs. 26-28. Male genital capsule of *Augochlorella striata*. Fig. 26, dorsal view; Fig. 27, ventral view (l_1: inner lobe of gonostylus; l_2: outer lobe of gonostylus; gn: gonostylus); Fig. 28, side view of genital capsule.

Figs. 29-30. Male genital capsule of *Augochlorella seminigra*. Fig. 29, dorsal view; Fig. 30, ventral view.

Figs. 31-36. Lobes of the gonostyli. Fig. 31, *A. bracteata*; Fig. 32, *striata*; Fig. 33, *persimilis*; Fig. 34, *gratiosa*; Fig. 35, *pomoniella*; Fig. 36, *edentata*.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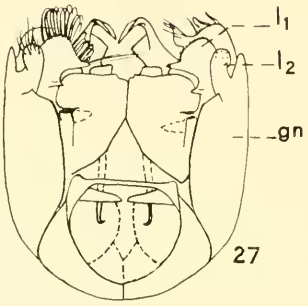
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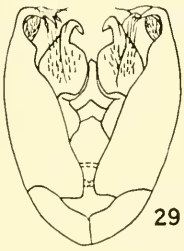
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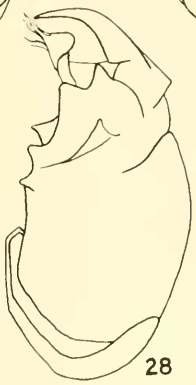
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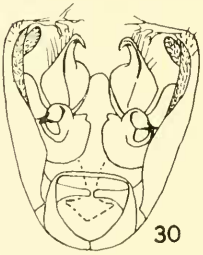
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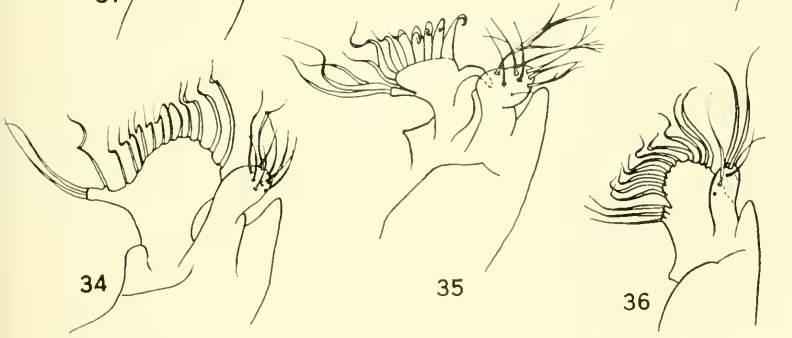
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not visible except when the longer hairs have been worn away and the surface is seen in profile. This latter pubescence is white in *Augochlorella* and may be rather dense in unworn specimens, especially on the head, posterior surface of the propodeum and metasoma. The longer hairs are white to golden-white, depending on the region of the body and on the individual specimen.

Male genitalia. The male genital capsule (Figs. 26-28) is basically similar for all Nearctic species but differs significantly in structure from that of *A. seminigra* of the *Pereirapis* group (Figs. 29-30). The only specifically variable structure on the capsule is the inner lobe of the gonostylus (l_1, Fig. 27). This lobe is essentially similar in all the eastern species (*aurata*, *striata*, *gratiosa*, *persimilis* and *bracteata*) (type 1, Figs. 31-34) but is distinctive for each of the remaining western and Mexican species (types 2-4, Figs. 35-39). In type 1, considerable variation occurs within species in the length of the attentuated, finger-like projection, the number of long setae, and the roundness and slope of the apical portion of the lobe. There are average differences in shape among the species, as seen in Figs. 31-36, but these differences are not constant and cannot be used as diagnostic characters. The number of setae is not constant but averages about 10 on the rounded portion of the lobe and 2 to 3 on the attenuation. The outer lobe (l_2, Fig. 27) is similar for all type 1 species and varies little except for the number of long, unbranched setae. The genitalia of the remaining (western and Mexican) species are described under those species.

Hidden sterna. Only three structural types are recognized among the eight species studied (Figs. 40-42), with all eastern species and *neglectula* belonging to type 1. Slight individual variations occur in type 1 (Fig. 40) that involve the degree of sclerotization, the shape of the apex, and the number and position of setae on the seventh sternum. The central thickening appears to be absent in *neglectula*. In *pomoniella* (Fig. 41), the sterna differs by the presence of a variably shaped knoblike median projection on the eighth sternum, by the minute setose projections on the distal arms, by the apparent lack of central thickening and the consistent lack of apical setae on the seventh sternum. In *edentata* (Fig. 42) the structure of the eighth sternum is similar to that of the eastern species, but the seventh sternum is elongate and truncated apically.

Eighth tergum. This tergum is hidden, mostly membranous, internal, usually closely adherent to the seventh tergum and attached by weakly sclerotized arms to the eighth sternum. There is a row of spiculate, finger-like pro-

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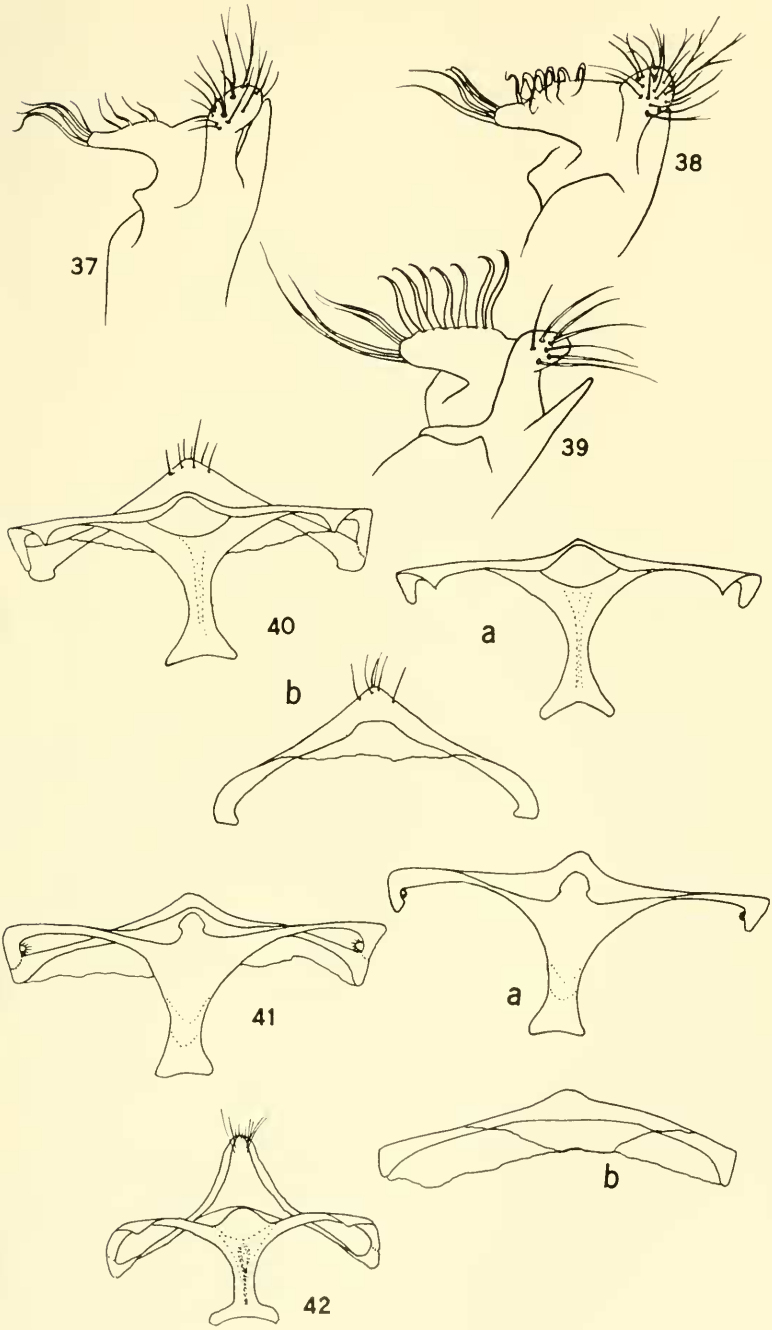
Figs. 37-39. Lobes of the gonostylus of *A. neglectula*. Figs. 37-38, *n. neglectula*; Fig. 39, *n. maritima*.

Figs. 40-42. Hidden metasomal sterna, a: sternum 7, b: sternum 8. Fig. 40, type 1, *A. striata*; Fig. 41, type 2, *pomoniella*; Fig. 42, type 3, *edentata*.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jections along the anterior (inner) edge when the sclerite is in its normal inverted position (Fig. 43). However, this whole structure may be everted, in which case the projections extend posteriorly to the outside (Figs. 44, 45). There are differences among species in the number, shape and spacing of the finger-like projections. All the eastern species as well as *pomoniella* belong to type 1 (Fig. 43) characterized by 10 to 14 closely arranged, densely setose projections with the entire tergum minutely setose. The projections are sometimes branched at the tips in *gratiosa*. In *neglectula* (Fig. 46) there are 8 to 9 short, thin, widely separated, and sparsely, minutely and inconspicuously pubescent projections. The membrane appears finely pubescent laterally but bare medially. In *edentata* (Fig. 47) the projections number 12 to 14 are long, thin and very sparsely setose. The arms are minutely pubescent, but the transverse part appears bare. The differences noted here are easily observable under 200× magnification of a compound microscope. Differences in the shape of the tergum, length and shape of the lateral arms, presence and location of punctures and arrangement and pattern of the pubescence are not considered of diagnostic value because of the fragile nature and eversibility of the entire structure. The eighth tergum is most easily removed with the genital capsule and seventh and eighth sterna to which it is attached.

OTHER CHARACTERS

Other characters were studied and rejected because the characters were identical in all species, because they were too variable intraspecifically to have any meaning, or because the measurements or definitions were not precise or reproduceable. A total of 20 characters, most with multiple character states, were used in a factor analysis of differences between females of *persimilis* and *striata*. Although none of the characters was rejected on the basis of this study, it was shown that those characters deemed most useful in species recognition were indeed most highly correlated with the species (used in the analysis as one of the characters). These most useful characters were located in the propodeal area.

Characters studied but seldom or not found useful among the nearctic species are:

Head: Ratio of clypeal length to width; protuberance of clypeus and supraclypeal area, color and shape of labrum; degree of rugosity of frontal area; roughening of vertex; relations between upper interocular, the interocellar

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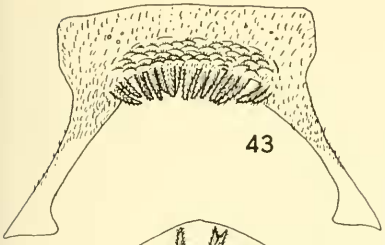
Figs. 43-47. Hidden eighth metasomal tergum. Fig. 43, *A. striata* (normal inverted position); Fig. 44, *gratiosa* (semi-everted); Fig. 45, *gratiosa* (everted position); Fig. 46, *neglectula*; Fig. 47, *edentata*.

Figs. 48-51. Male hind basitarsus, inner view. Fig. 48, *A. striata*; Fig. 49, *neglectula*; Fig. 50, *persimilis*; Fig. 51, *gratiosa*.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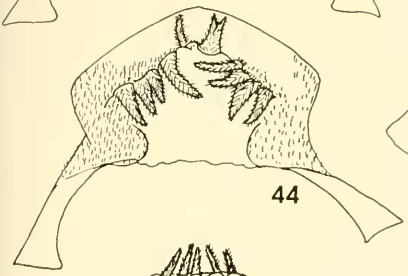
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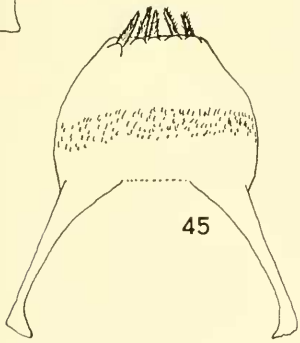
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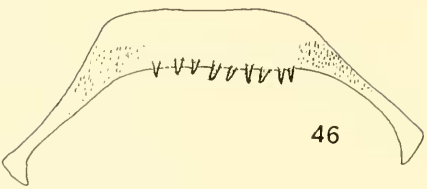
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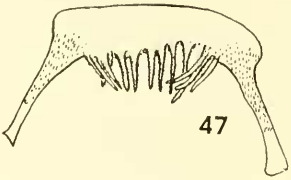
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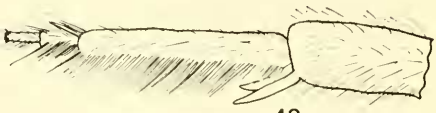
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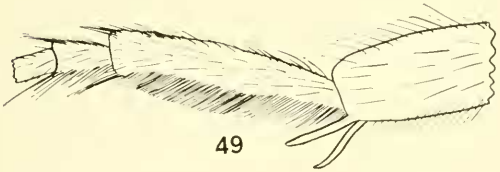
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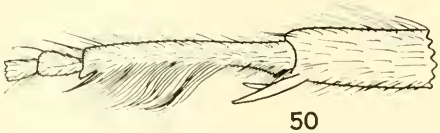
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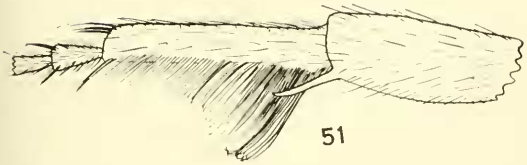
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and the ocellocular distances; smoothness, color and length of pubescence of genal area; antennal contrasts in color of different segments.

Thorax: The angle between the dorsum of the scutum and the slope of the propodeal disc; wing length; color, size, shape of the tegula; precise measurements and comparisons of size and spacing of punctures anteriorly, centrally, laterally and at anterolateral angles of the scutum; sculpture, color and smoothness of the scutellum; sculpture, color and smoothness of each part of the pleuron; size and spacing of the propodeal striations; ratio of dark to light areas on the femora and tibiae of the male; length to width ratios of the hind tibia and tarsal segments; color of the basitibial plate.

Metasoma: Detailed color variations of the terga; descriptions, measurements and comparisons of size and spacing of punctures and surface markings on all terga; punctures and lineations or other markings on the sterna; depth of the emargination of fourth sternum in males; comparisons of certain structures of the genital capsule of males—length of the attenuation of the inner lobe; roundness and height of the apex or crown of the inner lobe; spacing and number of setae on the inner lobe; shape, location and area of fusion of other lobes and processes on the gonostylus; comparison of profiles (side view) of the capsule.

SPECIES GROUPS

The Nearctic group of species (i.e., *Augochlorella s. str.*, not *Pereirapis*) includes both Neotropical and Nearctic species although only the Nearctic species are considered at this time. This group is divisible into eastern, western and southern subgroups, each showing certain distributional and morphological affinities. The only species included in this work from the southern subgroup is *edentata*, but there are undoubtedly other species to the south. The western or "*pomoniella* subgroup" contains *pomoniella* and *neglectula*. The eastern or "*striata* subgroup" consists of *aurata*, *striata*, *persimilis*, *gratiosa* and *bracteata*.

The *pomoniella* subgroup ranges from northern California southeast into Arizona and New Mexico in the United States and at least as far south as Costa Rica and Panama. The *striata* subgroup is found from south central and southeastern Canada through the eastern, midwestern and southern United States and as far west as Colorado and New Mexico. Except for *bracteata*, none of the included species ranges into Mexico.

Morphological characters separating the *striata* and *pomoniella* subgroups involve the shape of the fourth metasomal sternum of males (margin straight in *pomoniella* subgroup, emarginate in *striata* subgroup) and the shape of the inner lobe of the gonostylus of the male genital capsule. The degree of morphological variation occurring within the two groups is also significant.

These characters and their relationships among the species are discussed under each taxon. It is quite probable that significant biological differences may be found between the subgroups, but as yet, only the biologies of *persimilis* and *striata* are known (see Ordway, 1965a; in press).

The species of the eastern subgroup seem more closely related to each other than are the two species of the western subgroup. In the *striata* subgroup there is greater morphological variation and intergradation among the species and the male genitalia are all essentially alike. In the *pomoniella* subgroup the male genitalia differ, and there is comparatively little variation and virtually no intergradation between the two species.

The relationship of *edentata* to the northern *Augochlorella* and to the *Pereirapis* group is not clearly understood. The female appears to belong to *Pereirapis* and has been placed in that group by Moure. The male, however (previously undescribed), has clypeal and genitalic characteristics of the northern species but in other respects looks similar to *Pereirapis*.

SPECIES ACCOUNT

Key to the species of *Augochlorella*

This key must be used in conjunction with the regional keys and the section entitled Regional Discussion because of the wide variability within species and the continuous or intergrading nature of all characters. The key for females will not work for all specimens since intermediates are found among many of the species and forms. The term "disc" in all cases refers to the dorsal area of the propodeum.

Females

1. Striae of disc reaching edge posteriorly, i.e., with little or no unstriated area between ends of striae and edge of disc (Figs. 57-63) 2
— Striae of disc not reaching edge posteriorly, with distinct unstriated region between ends of striae and edge of disc (Figs. 64, 67, 69) 11
2. Scutum coarsely punctate and strongly rugose anteriorly (Fig. 77) 3
— Scutum with small, distinctly separated punctures, finely roughened to weakly rugose anteriorly (Fig. 78) 9
3. Striae of disc fine and close together; disc at least weakly bracket-shaped (Figs. 57, 58), length less than or only slightly longer than metanotum ..... *aurata, gratiosa, striata* A (see regional keys)
— Striae of disc coarse, close together to widely separated; disc variably shaped, longer than metanotum ..... *(striata)* 4
4. Posterior edge of disc sharply angulate (Fig. 21) or abruptly rounded (Fig. 22); disc sharply pointed medially; length of disc less than 1.5 times that of metanotum (Fig. 60) ..... *striata* A

— Posterior edge of disc gradually rounded or at most abruptly rounded, not sharply pointed medially, or if so, length more than 1.5 times as long as metanotum 5

5. Disc at least weakly bracket-shaped, length equal to or only slightly longer than metanotum (Fig. 71) ..... *striata* D

— Disc V-shaped, U-shaped or semicircular (Figs. 16-19) 6

6. Disc obtusely and bluntly V-shaped (Figs. 15, 63), length 1.5 to 2 times that of metanotum ..... *striata* B

— Disc U-shaped or semicircular, or if V-shaped then less than 1.5 times length of metanotum 7

7. Shape of disc semicircular or U-shaped; edge smoothly and gradually rounded posteriorly (Figs. 24, 62) without distinct difference in sculpture between dorsal and vertical surfaces ..... *striata* C

— Shape of disc variable, posterior edge slightly raughened, abruptly angulate (Figs. 22, 23) or with distinct contrast in sculpture between dorsal and vertical surfaces 8

8. Disc roundly V-shaped with medial striae ending abruptly at posterior edge ..... *striata* D

— Disc semicircular with striae ending gradually near posterior edge ..... *striata* C

9. Shape of disc semicircular (Fig. 66); scutum with small, distinctly separated punctures, space between punctures smooth and shiny (Fig. 78) (Texas and Mexico only) ..... *bracteata*

— Shape of disc at least weakly bracket-shaped (Figs. 57, 58); scutum with punctures irregular in size and shape, very close or contiguous with little or no smooth shiny space between (Fig. 81), giving scutum a slightly roughened appearance 10

10. Posterior vertical surface of propodeum finely and evenly granular or smooth (Fig. 74), length of disc equal to or slightly greater than length of metanotum ..... *aurata*

— Posterior vertical surface of propodeum irregularly or coarsely granular with minute irregular ridges (Fig. 76), length of disc equal to or less than metanotum ..... *gratiosa*

11. Scutum with small, distinct punctures, surface between punctures smooth, or minutely roughened and without distinct punctures (Figs. 78, 79) 12

— Scutum with surface rough, coarsely punctate or rugose, at least anteriorly ..... *persimilis, striata* C, *neglectula, pomoniella* (see regional keys)

12. Antenna with yellow tip; scutum without distinct punctures (Fig. 79); propodeal disc more than 1.5 times as long as metanotum ..... *edentata*

— Antenna with dark tip; scutum with close, distinct punctures (Figs. 78, 80); propodeal disc 1.5 times as long as metanotum or less 13

13. Striae occupying three-quarters the length of the disc or less as in Figure 69, with posterior edge of disc smooth and shiny ..... *pomoniella*

— Striae occupying more than three-quarters the length of the disc, posterior edge roughened and dull 14

14. Posterior vertical surface of propodeum finely and evenly granular or smooth; tegula shiny without distinct punctures ..... *bracteata*
— Posterior vertical surface of propodeum roughened with horizontal rugae extending across posterolateral corners; tegula dull, with small but distinct punctures ..... *neglectula maritima*

Males

No attempt is made to separate males of *striata* into forms A to D, since only a few can be so classified. Differences among these forms, when present, are explained at the end of the description of *striata*.

1. Fourth metasomal sternum with apical margin straight 2
— Fourth metasomal sternum with apical emargination 4
2. Metasomal terga green or blue; first sternum with metallic reflections 3
— Metasomal terga brown; first sternum without metallic reflections .. *edentata*
3. Posterolateral corner and lateral vertical surface of propodeum smooth, with punctures; frons without bluish reflections ..... *pomoniella*
— Posterolateral corner and lateral vertical surface of propodeum rough or rugose, not punctate; frons with bluish reflections ..... *neglectula*
4. Hind basitarsus with erect hairs of two distinctly different lengths (exclusive of basal tuft), longest hairs at least twice as long as width of segment, usually curved at tips (Figs. 50-51) 5
— Hind basitarsus with erect hairs of similar lengths (exclusive of basal tuft), 1.5 times as long as width of segment or less; all hairs straight (Figs. 48-49) ..... *aurata, striata, bracteata* (see regional keys)
5. Basal third of hind basitarsus without long erect hairs; longest hairs on apical two-thirds about twice as long as width of segment (Fig. 50); last antennal segment similar in color to preceding segment, not entirely dark brown; fifth metasomal sternum without greenish reflections ..... *persimilis*
— Basal third of hind basitarsus bearing long curved hairs, four times as long as width of segment (Fig. 51); least antennal segment entirely dark brown; fifth metasomal sternum with greenish reflections ..... *gratiosa*

Regional Keys

If the user of the keys is directed to the Regional Keys by the main keys, he should select the region to which his specimens belong and continue keying at the appropriate couplet.

Northeast (Canada, Maine, New Hampshire, Vermont, Massachusetts, Connecticut, Rhode Island, Pennsylvania, New York, New Jersey.)

Females

From couplet 3: all specimens are *striata* A.

From couplet 11: all specimens are *striata* C.

MALES

From couplet 4: all specimens are *striata*.

NORTH CENTRAL (Ohio, Indiana, Michigan, Illinois, Kentucky, Kansas, Colorado, Wyoming, Nebraska, Iowa, Wisconsin, Minnesota, North Dakota, South Dakota, Montana.)

FEMALES

From couplet 3: all specimens are *striata* A.

From couplet 11: intergrades occur throughout the region but particularly in Illinois, Indiana, Missouri, Nebraska and Kansas. Check regional discussion for description of variations.

Surface of disc beyond striae smooth; striae extending almost to posterior edge of disc (Fig. 68) ..... *striata* C

Surface of disc beyond striae usually linearly roughened; striae extending about four-fifths or less the length of disc (Fig. 64) ..... *persimilis*

MALES

From couplet 4: all specimens are *striata*.

SOUTHEAST (Florida, Georgia, South Carolina, North Carolina, Virginia, West Virginia, Maryland, Delaware.)

FEMALES

From couplet 3:

A. Posterior vertical surface of propodeum finely and evenly granular or smooth (Fig. 74); length of disc equal to or slightly greater than length of metanotum ..... B

— Posterior vertical surface of propodeum irregularly or coarsely granular (Fig. 76); length of disc equal to or shorter than metanotum ..... *gratiosa*

B. Striae of disc thick, regular, straight or slightly wavy (Fig. 60) ..... *striata* A

— Striae of disc fine, close, irregular (Fig. 57) ..... *aurata*

From couplet 11: nearly all specimens are *persimilis* from this area as *striata* C is not common and is usually large (more than 6 mm long) with characters not usually confused with those of *persimilis*. Neither one has been seen from Florida.

Striae of disc almost reaching posterior edge; surface beyond striae smooth and shiny or at most minutely reticulated (Fig. 68) ..... *striata* C

Striae extending about three-fourths the length of disc medially, area beyond striae usually finely and linearly roughened parallel to edge of disc (Fig. 64) ..... *persimilis*

MALES

From couplet 4:

Striae of disc fine and close together (Fig. 57); scutum with small, distinct but crowded punctures, weakly rugose anteriorly .... *aurata*

Striae of disc coarse, widely or closely spaced (Figs. 59, 60, 63);

scutum smooth with large, widely spaced punctures or rough and coarsely punctate, coarsely rugose anteriorly ..... *striata*

South Central (Texas, Louisiana, Mississippi, Alabama)

Females

From couplet 3:

Posterior vertical surface of propodeum uniformly and finely granular (Fig. 74); length of disc equal to or longer than metanotum medially, striae straight or irregular and indistinct; apex of clypeus less than one-third brown; in Texas, first metasomal tergum strongly punctate (Fig. 82) ..... *aurata*

Posterior vertical surface of propodeum roughly or irregularly granular (Fig. 76); length of propodeal disc equal to or shorter than metanotum, striae straight and regular (Fig. 58); clypeal apex more than or less than one-third brown; in Texas, first metasomal tergum finely punctate (Fig. 83) .... *gratiosa*

From couplet 11:

A. Posterior vertical surface of propodeum and posterolateral corners finely and transversely rugose; south-western Texas ..... *neglectula*

— Posterior vertical surface of propodeum and posterolateral corners smooth and shiny or finely granular ..... B

B. Striae extending almost to posterior edge of disc; surface beyond striae smooth or slightly irregular or roughened .... *striata* D

— Striae extending about three-fourths the length of disc; surface beyond striae usually linearly roughened ..... *persimilis*

Males

From couplet 4:

Scutum finely roughened anteriorly; posterolateral corners and lateral vertical face of propodeum punctate to weakly punctorugose ..... *bracteata* (Texas only)

Scutum with anterior margin coarsely rugose to areolate; posterolateral corners and lateral vertical surface of propodeum rough to rugose ..... *striata* (throughout the area)

West (California, Nevada, Utah, Arizona, New Mexico) and Mexico.

Females

From couplet 3: none of these species range into this region.

From couplet 11:

A. Scutum with large, distinct, but close punctures; surface between punctures smooth; posterolateral corners of propodeum prominent, smooth and shiny (Fig. 69); posterior vertical surface of propodeum smooth, finely punctate (Fig. 73); striae of disc short, rarely extending more than two-thirds the length of the disc medially, surface beyond striae smooth and minutely reticulated (Fig. 69) ..... *pomoniella*

— Scutum coarsely punctate; posterolateral corners of propodeum rough, dull, not prominent (Fig. 70); posterior vertical surface of propodeum finely roughened to weakly rugose (Fig. 75); striae of disc reaching about three-fourths the length of disc medially, surface beyond striae dull and granular ..... B

B. Tegula shiny, oval, smooth, without distinct punctures ..... *neglectula neglectula*

— Tegula dull, oblong, distinctly and roughly punctate (Mexico only) ..... *neglectula maritima*

MALES

From couplet 4: all Mexican specimens are *bracteata;* all western specimens are *striata.*

Augochlorella pomoniella (Cockerell)

Augochlora pomoniella Cockerell, 1915, Pomona Jour. Ent. Zool. 7:232 (descr.); Cockerell, 1916, Pomona Jour. Ent. Zool. 8:51 (descr., distr.); Bray, 1917, Pomona Jour. Ent. Zool. 9:99 (list); Sandhouse and Cockerell, 1924, Proc. California Acad. Sci. (4)13:339 (distr., key); Cockerell, 1926, Ann. Mag. Nat. Hist. (9)18:624 (distr.); Cockerell, 1927, Pan-Pacific Ent. 3:162 (distr., descr.); Michener, 1936, Pan-Pacific Ent. 12:172 (distr.); Cockerell, 1937, Amer. Mus. Novitates 948:12 (distr.); Michener, 1937, Ann. Mag. Nat. Hist. (10)19:314 (descr.); Cockerell, 1939, Proc. California Acad. Sci. (4)23:429, 431 (distr., fl.); Cockerell, 1939, Bull. So. California Acad. Sci. 38:139 (distr.); Cockerell, 1941, Proc. 6th Pacific Sci. Congr. 4:289 (distr.); Linsley, MacSwain, Raven, 1963, Univ. California Pub. Ent. 33:44 (fl.).

Augochlora (Augochlorella) pomoniella pomoniella: Michener, 1951, *in* Muesebeck *et al.* U.S. Dept. Agr., Agr. Monogr. 2, p. 1125 (list).

Augochlorella pomoniella: Sandhouse, 1937, Jour. Washington Acad. Sci. 27:69, 71 (key, tax.); Michener, 1954, Bull. Amer. Mus. Nat. Hist. 104:55 (descr.); Linsley, 1962, Proc. 1st Internat. Sympos. on Pollination, Copenhagen 1960, p. 194 (fl.).

Augochlorella pomoniella pomoniella: Krombein, 1958, U.S. Dept. Agr., Agr. Monogr. 2, 1st suppl. p. 232 (list).

Augochlora utahensis Michener, 1937, Ann. Mag. Nat. Hist. (10)19:314 (descr.).

Augochlora (Augochlorella) pomoniella utahensis: Michener, 1951, *in* Muesebeck *et al.,* U.S. Dept. Agr., Agr. Monogr. 2, p. 1125 (list).

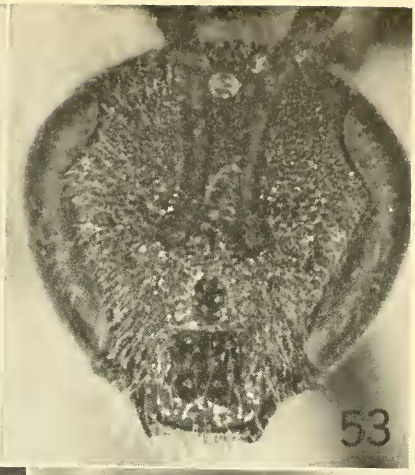
Types. Augochlora pomoniella, holotype female, from Aliso Canyon (2 miles from Laguna Beach) [Orange County], California (R. LaFollette) is in the collection of the U.S. National Museum. *Augochlora utahensis,* holotype female, from Rockville [Washington County], Utah, May 7, 1931 (I.

FIGS. 52-54. Shapes of heads of *Augochlorella.* Fig. 52, *neglectula,* longer than wide; Fig. 53, *persimilis,* as long as wide; Fig. 54, *pomoniella,* wider than long.

FIG. 55. Front view of head of *A. edentata.*

FIG. 56. First and second metasomal terga with waxlike exudate.


52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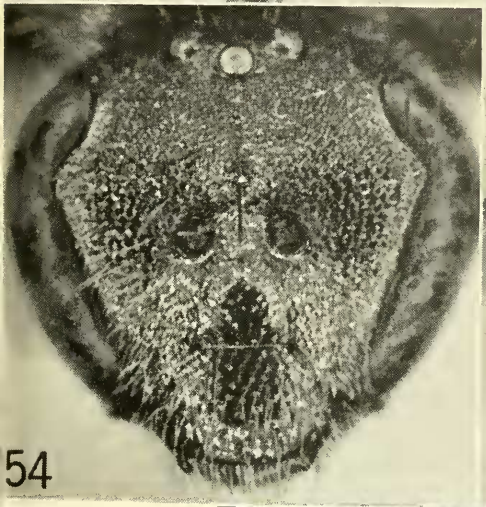
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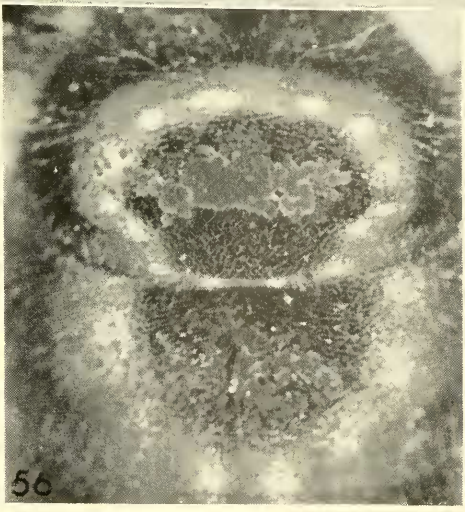
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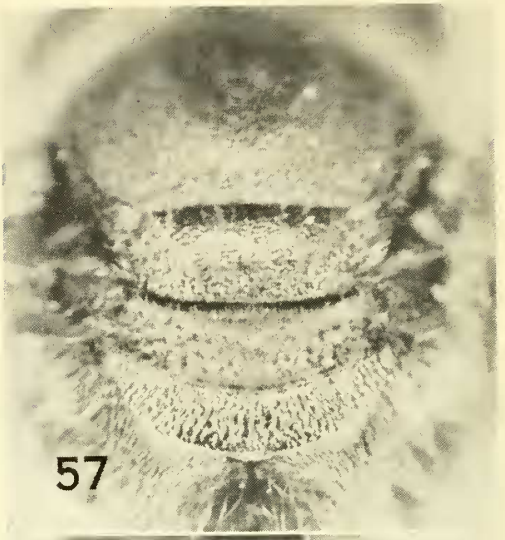


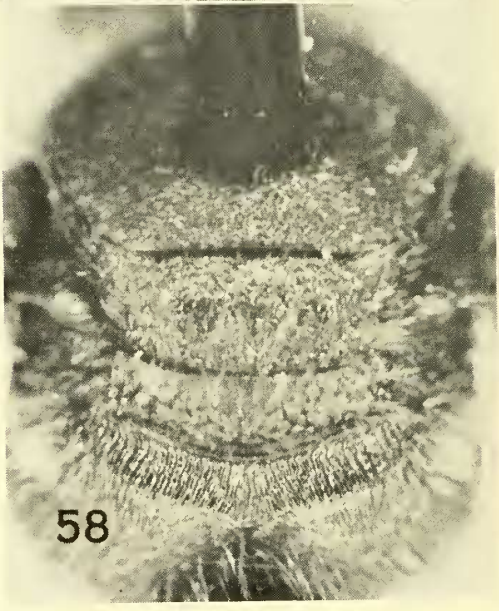


FIG. 57. Propodeal disc of *A. aurata.*
FIG. 58. Propodeal disc of *A. gratiosa.*

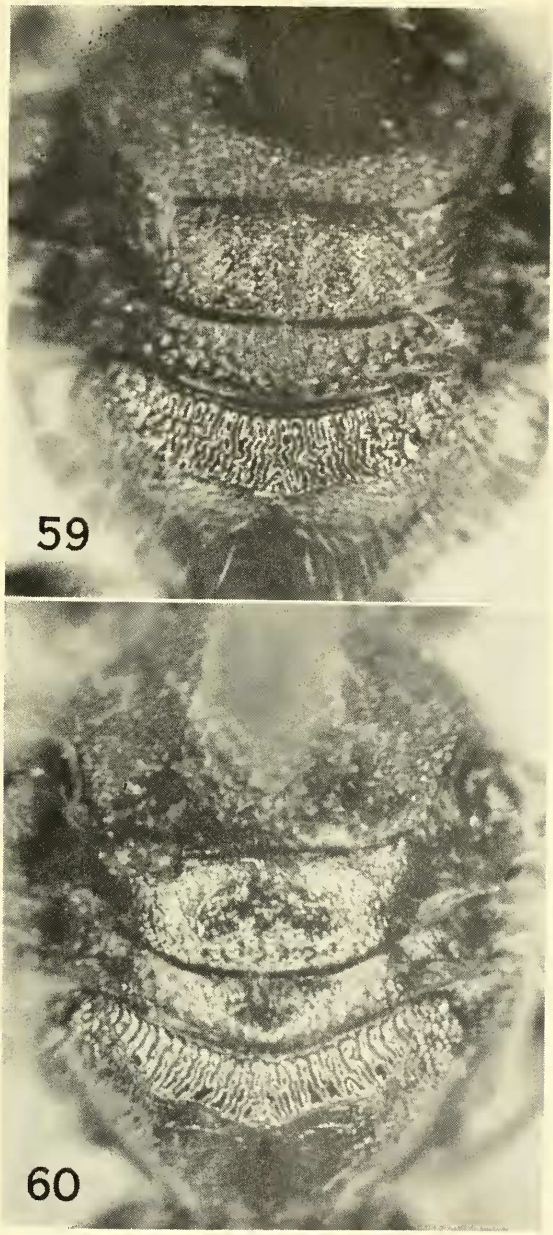
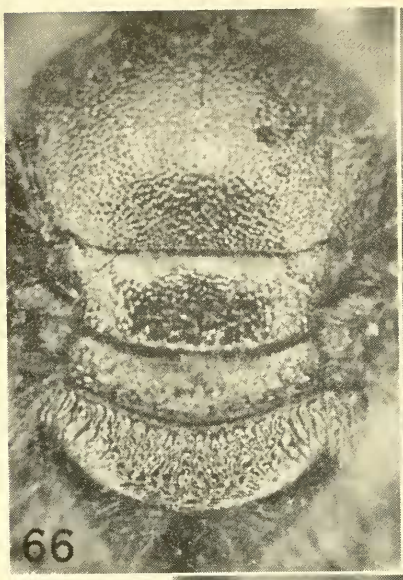


Fig. 59. Propodeal disc of *A. striata* A from Florida.
Fig. 60. Propodeal disc of *A. striata* A from east coast (standard).

FIG. 61. Propodeal disc of *A. striata* c.
FIG. 62. Propodeal disc of *A. striata* c (standard).

Fig. 63. Propodeal disc of *A. striata* B (standard).
Fig. 64. Propodeal disc of *A. persimilis*.
Fig. 65. Propodeal disc of *A. striata* B-C intermediate.



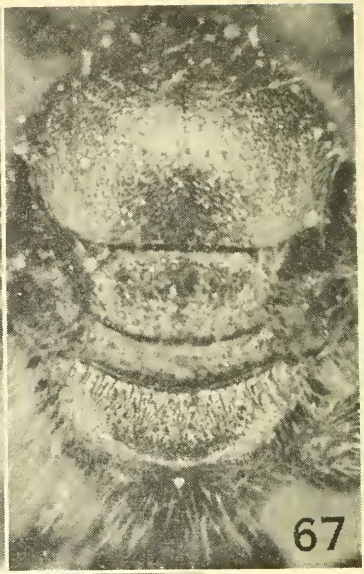


FIG. 66. Propodeal disc of *A. bracteata.*
FIG. 67. Propodeal disc of *A. edentata.*
FIG. 68. Propodeal disc of *A. striata* c-*persimilis* intermediate.

FIG. 69. Propodeal disc of *A. pomoniella.*
FIG. 70. Propodeal disc of *A. neglectula.*

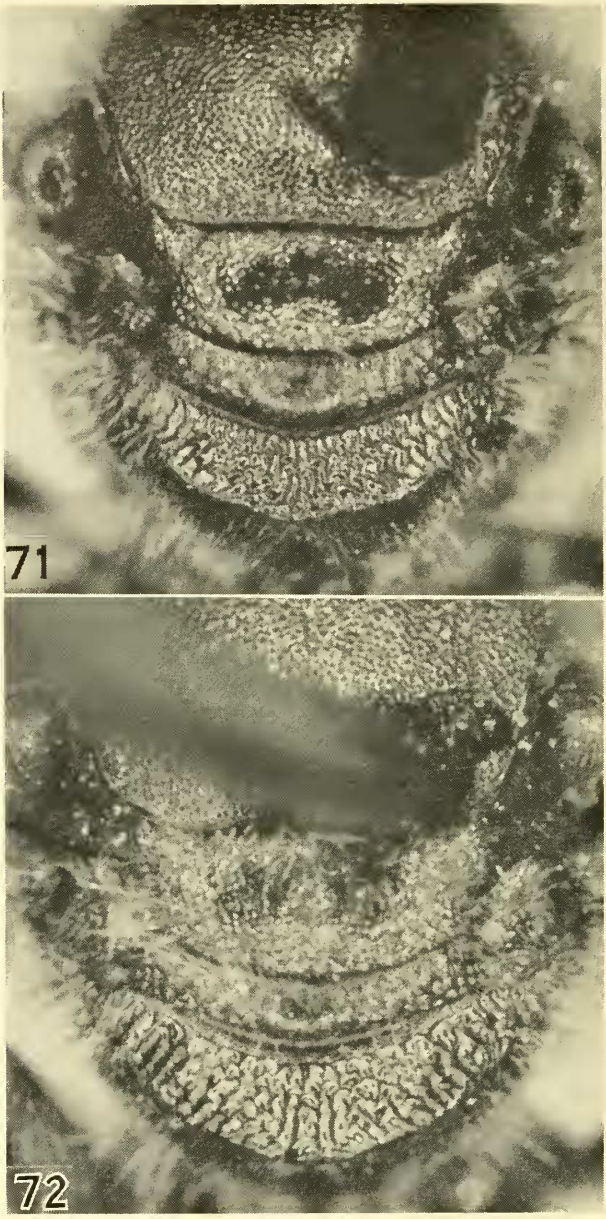


FIG. 71. Propodeal disc of *A. striata* D (standard).
FIG. 72. Propodeal disc of *A. striata* B-D intermediate.

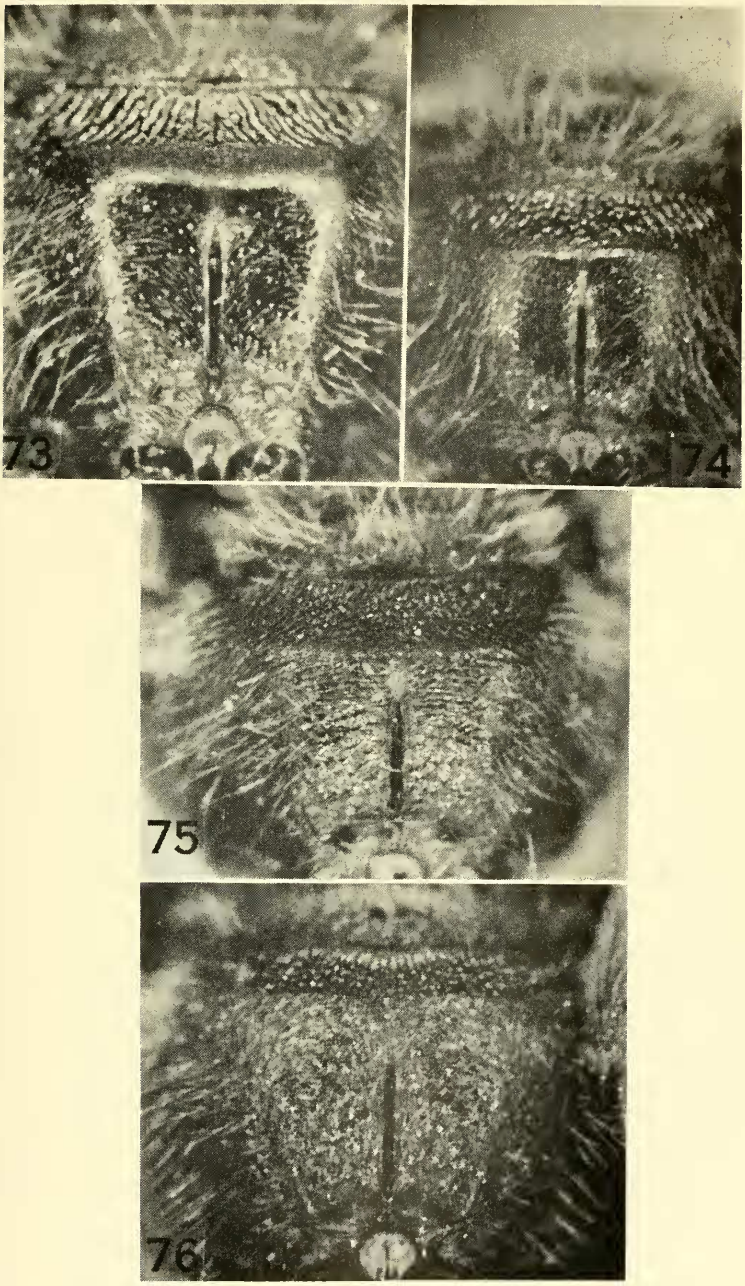


FIG. 73. Posterior vertical surface of propodeum, *A. pomoniella.*
FIG. 74. Posterior vertical surface of propodeum, *A. persimilis.*
FIG. 75. Posterior vertical surface of propodeum, *A. neglectula.*
FIG. 76. Posterior vertical surface of propodeum, *A. gratiosa.*

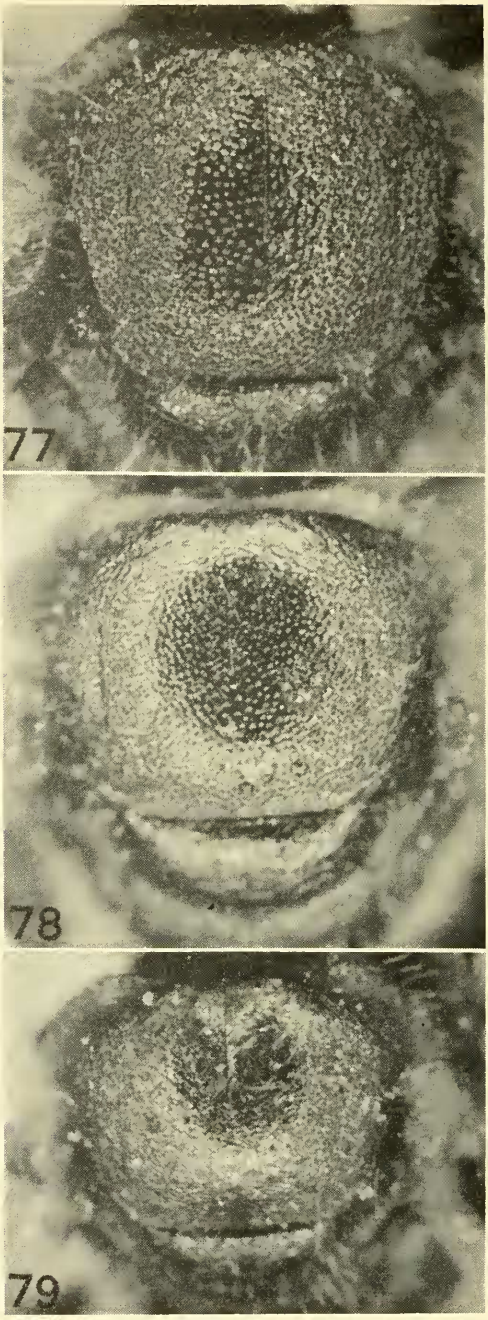


FIG. 77. Mesoscutum, *A. striata.*
FIG. 78. Mesoscutum, *A. bracteata.*
FIG. 79. Mesoscutum, *A. edentata.*

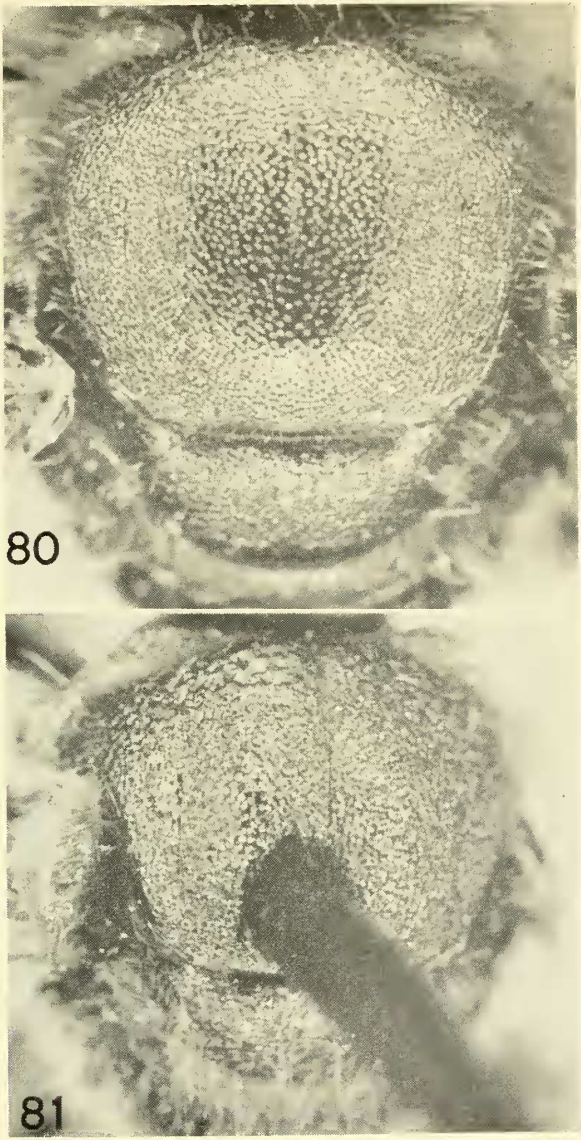


FIG. 80. Mesoscutum, *A. pomoniella*.
FIG. 81. Mesoscutum, *A. gratiosa*.

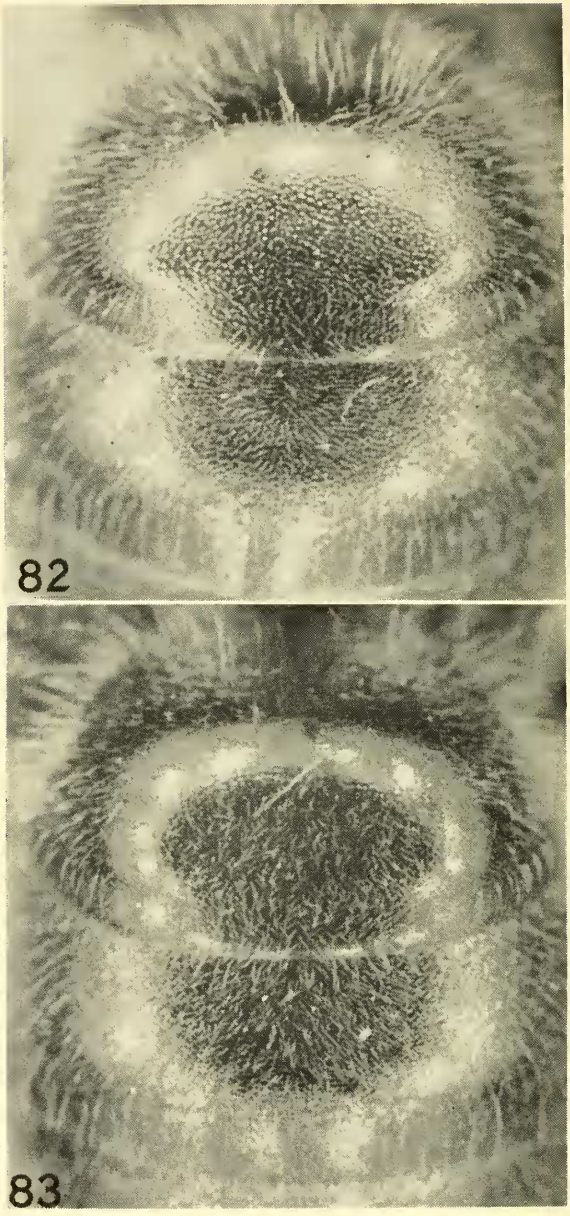


FIG. 82. Metasomal punctures, *A. aurata*.
FIG. 83. Metasomal punctures, *A. gratiosa*.

Wilson), on *Datura*, and one paratype female are in the Snow Entomological Museum, The University of Kansas.

Description. Female: (1) Length 7 to 9 mm; head width 1.8 to 2.6 mm, averaging 1.90 mm, usually wider than long (rarely as wide as long). (2) Color bright green to blue-green; frons often with slight bluish reflections; metasoma similar in color to head and thorax or darker or browner in Mexican specimens. (3) Mandible usually with basal half dark brown, lighter brown becoming ferruginous apically, with or without metallic reflections basally. (4) Clypeus about twice as wide as long; basal half green with large, widely spaced punctures, closer basally; apical half dark brown or black and slightly beveled, with large elongate punctures; surface between punctures usually smooth and shiny, sometimes minutely roughened. (5) Supraclypeal area shiny and irregularly punctured; surface smooth or sometimes minutely roughened. (6) Paraocular area punctorugose to finely rugose below level of antennae, more coarsely rugose above. (7) Antenna entirely dark brown; flagellum often slightly lighter below than above; pedicel as long as broad; first flagellar segment almost twice as wide as long. (8) Scutum regularly and densely punctate; punctures small, deep and close; anterior margin roughened medially, becoming weakly rugose at anterolateral angles. (9) Tegula less than twice as long as wide. (10) Scutellum with small, deep, close punctures. (11) Pleuron rugose, more coarsely so anteriorly. (12) Propodeum with disc 1.5 times as long as metanotum; outline of disc U-shaped, profile type 5, posterior edge abruptly rounded, shiny and smooth; disc extending slightly onto posterior surface of propodeum and particularly onto posterolateral corners; striae wavy, irregular, moderately coarse, extending about two-thirds the length of disc medially, usually attaining edge at extreme lateral corner; surface beyond striae minutely reticulate; posterior vertical surface smooth and shiny, sparsely and minutely punctured; posterolateral corners prominent, shiny, smooth, with few widely spaced punctures; lateral surface finely and linearly rugose anteriorly, weakly punctate toward posterior angles. (13) Legs brown, fore and hind coxae and trochanters with strong metallic reflections, femora usually with weak metallic reflections. (14) First metasomal tergum polished and brilliant, punctures fine and widely spaced anteriorly, smooth and shiny dorsally with punctures small, distinct, numerous, closely and regularly spaced; other terga with minute, often indistinct punctures close together; first sternum without metallic reflections. (15) Pubescence white on head, pale, golden to white on vertex, thorax, metasoma and legs; pubescence short and sparse on genal area, denser and coarser in Mexican specimens.

Male: (1) Length 9 mm; head with 1.75 to 2.25 mm, averaging 2.18 mm, width equal to length. (2) Color bright green to blue-green; frons without blue reflections on green specimens; metasoma dark green, usually darker

than rest of body. (3) Mandible usually with metallic reflections basally. (4) Clypeus with punctures large, widely and irregularly spaced, surface between punctures usually smooth and shiny. (5) Supraclypeal area punctate to punctorugose below antennae, usually smooth, shiny and sparsely punctate basally. (6) Paraocular area with small distinct punctures below level of antennae, finely ruguose above. (7) Flagellum dark brown above, yellow-brown below; scape, pedicel and usually first flagellar segment dark brown in the United States and some Mexican specimens, last one or two flagellar segments often slightly darker than preceding segments; pedicel and first flagellar segment about equal in size, each about 1.5 times as wide as long. (8) Scutum shiny and smooth, uniformly punctured; punctures distinct, separated by less than a puncture width medially, more crowded at periphery than at center in specimens from areas outside of California; anterior margin roughened or finely rugose, becoming slightly more coarsely so at lateral angles. (9) Tegula twice as long as wide, entirely pale yellow in some Mexican specimens. (10) Scutellum shiny, roughened and punctate; punctations generally irregular in size and spacing. (11) Pleuron rugose to punctorugose, becoming areolate anteriorly. (12) Propodeum with disc 1.5 times as long as metanotum; outline of disc truncately to obtusely U-shaped; disc nearly horizontal and slightly concave, slightly lower at posterolateral corners than posteromedially; posterior edge abruptly rounded, smooth and shiny; striae rather coarse, distinct, wavy, extending about two-thirds length of disc medially or nearly to margin when median striae depressed, reaching edge laterally, often extending onto lateral surfaces of propodeum; surface of disc beyond striae shiny, smooth, minutely reticulate, smooth area extending onto posterior surface; posterior surface of propodeum shiny, usually slightly roughened with shallow, widely spaced punctures of variable size and density, distinct to indistinct; posterolateral corners closely and shallowly punctate; lateral surface regularly and distinctly punctate with surface between punctures smooth and shiny. (13) Legs brown, coxae, trochanters, femora and tibiae with metallic reflections; hind basitarsi with erect hairs of uniform length and density from base to apex, about as long as width of segment; basal tuft absent. (14) Metasomal terga dark green with apical margins slightly depressed, narrowly brown. First tergum polished anteriorly with numerous widely spaced punctures, smooth, usually dull dorsally, punctures small and close; second and third terga dull, punctures small and close; sterna light brown, minutely pubescent, hairs often longer and denser at apical margins than elsewhere, less so medially than laterally; first sternum usually with feeble metallic reflections; apical margins of all sterna straight or slightly convex. (15) Pubescence white. (16) Genital capsule as in Figures 26, 27, 35, type 2; inner lobe of gonostylus "fan-shaped," bearing variable number (usually about 8) of large heavy setae, inner portion divided to form finger-

like section with two to five setae (usually 2 or 3); separation deep or shallow (so that "finger" may appear long or short, but always evident); sterna 7 and 8 without setae, variable in shape, 8 with broadly rounded basal edge medially, not truncate (Fig. 41b); 7 produced into knob-shaped lump medially, each arm with minute setose protuberance on distal inner angle (Fig. 41a); tergum 8 of type 1 (Fig. 43).

Comparisons. A. pomoniella is, perhaps, the most distinctive of all the North American *Augochlorella*. It is the largest (Fig. 86), smoothest and most brilliant of the species and the least variable. It seems most closely related to *neglectula*, although the male genitalia show closer affinities with those of the eastern species. Both male and female can be distinguished from *neglectula* by the more widely separated and larger scutal punctures and the generally smooth body surface, the greener legs, the polished posterior part of the propodeal disc and posterolateral corners, the smooth posterior propodeal surface, and in the males by the genitalia (distinguishable from all other North American species) and the sternal punctures and setae.

No *pomoniella* were found that would be confused with any other species.

Variation. Californian specimens, together with those from Nevada, both male and female, are the most morphologically stable of any species. Variability in size and color increases in Arizona and Mexico, where specimens tend to be smaller with the brown areas paler.

Specimens are larger in California (mean head width=2.33 mm) than in Mexico or Arizona (mean head width=2.07 mm) (Fig. 84) while females from Utah are about the same size as in California. Differences noted by Michener (1937) represent normal variations found not only among individuals from Utah but also in Californian material.

The metasoma of both males and females is noticeably darker in Mexican specimens than in specimens from the United States, with a greater tendency for the brown to dominate the green in males or brown to become black in females. Other brown structures, such as the mandibles, tarsi and tegulae, are paler in males from Mexico than in those from the United States, so that on the mandible, the dark brown area is restricted to the basal portion, and the tarsi of most specimens are lighter in color than other parts of the legs, contrasting with the uniformly dark brown legs of specimens from the United States. One series of nine specimens from Yucatan (13*) had both tibiae and tarsi pale although the tibiae were normal in the two other Yucatan males examined. All male specimens from Yucatan and Sonora had pale testaceous tegulae, although specimens from other parts of Mexico were normal. None of the females showed these variations in color.

* See Table 1.

Thoracic punctation is uniform both in size and spacing in males from California, but in Arizona and Mexico the punctures are closer together and irregular in size at the periphery of the scutum. Females vary little in this respect.

The surfaces of the head and thorax are dull and finely roughened by minute reticulations in many female specimens from Mexico. This roughening is most apparent on the supraclypeal area, clypeus, scutum and scutellum. In addition, the clypeus is entirely brown or black or the brown area extends medially to the base. Such variants were not found in Baja California; only 1 of 28 specimens from Sonora showed such characters, but all 27 specimens from other Mexican states showed them in varying degrees.

As with other species of *Augochlorella*, the propodeal area shows the greatest amount of variation but even this is less than in other species and there is no geographical trend or seasonal pattern in the variation. The striae of the disc are distinct in all males but in females there are occasional individuals in which the striae are fine, weak, or barely recognizable. The striae normally extend half the length of the disc, although in about one-third of the specimens they are longer medially and almost attain the edge of the disc. Such length is more noticeable in the males where the median area is slightly depressed when this condition occurs.

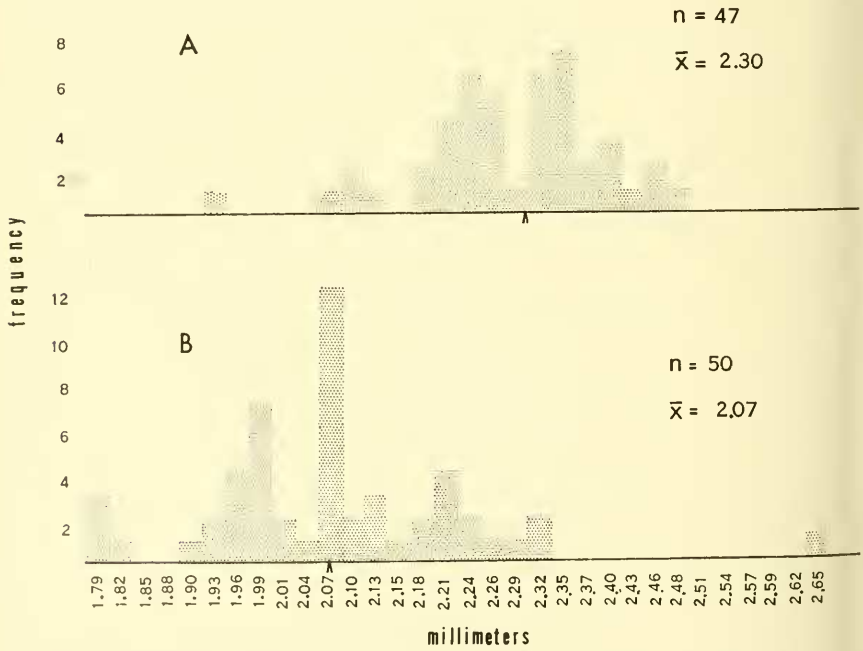


FIG. 84. Measurements of head widths of females of *A. pomoniella*. A. From California and Utah. B. From Arizona and Mexico.

Distribution. From northern California just north of San Francisco and western Nevada, southward through central and southern California; Washington Co., Utah, throughout the western half and southern part of Arizona; Baja, California, the west coast of Mexico to Chiapas and eastward to Yucatan, southward into Guatamala and Costa Rica (Map: Fig. 85).

A total of 118 males and 631 females have been seen. ARIZONA: *Cochise Co.*, 5 ♀ (Huachuca Mts.: Mouth of Carr Canyon; 7 mi. SW. Wilcox; Benson) (July, September); *Coconino Co.*, 2 ♂, 26 ♀ (Grand Canyon: Indian Garden ca. 3800 ft., Phantom Ranch ca. 2500 ft., South Rim 6800 ft.; Supai; Havaisu Canyon 3500 ft.) (June-August); *Maricopa Co.*, 1 ♂, 7 ♀ (Granite Reef Dam; 25 mi. E. Gila Bend; 20.7 mi. S. Gila Bend; Tempe) (March, July, September); *Mohave Co.*, 1 ♀ (Grand Canyon, mi. 179.2 at Lava Falls) (June); *Pima Co.*, 22 ♂, 78 ♀ (Tucson; Sta. Catalina Mts.: Pepper Sauce Canyon, Sabino Canyon, Sabino Basin 3800 ft., Ventana Canyon, Cape Canyon, Hitchcock Highway mile posts No. 5, 6, 8, 9, 5500 ft.; Saguaro Nat. Mon.; 18 mi. W. Sells; 5 mi. N. Tucson; 20 mi. E. Tucson; Lowell Ranger Sta. 2700 ft.; Sahuarita; Baboquivari Mts., Kits Peak Rincon; Sierritas 31° 51′ N. 111° 16′ W.; Black Dike Prspct. ca. 3750 ft.; Tanque Verde; Continental; Quitobaquito, Organ Pipe Nat. Pk.) (March-November); *Pinal Co.*, 4 ♂, 8 ♀ (Superior; 20 mi. W. Casa Grande; Florence Jct.; Coolidge; Río Aravaipa 2500 ft.) (February-March, June-July); *Santa Cruz Co.*, 3 ♀ (Coyote Mts. 31° 58′ N. 111° 29′ W., ca. 3500 ft.; Sonoita) (July-August); *Yavapai Co.*, 2 ♀ (Seligman; 3 mi. N. Rock Spr.) (July). CALIFORNIA: *Alameda Co.*, 5 ♀ (Tesla) (October); *Calaveras Co.*, 2 ♀ (Murphys 2500 ft.); *Contra Costa Co.*, 2 ♀ (Mt. Diablo) (July); *Fresno Co.*, 2 ♀ (Coalinga; Orange Cove) (April-May); *Inyo Co.*, 3 ♂, 63 ♀ (Lone Pine; Darwin Falls; Mazourka Canyon; Panamint Mts., Surprise Canyon; 7 mi. W. Westgard Pass; Death Valley; 5 mi. W. Lone Pine; Big Pine; Independence; Payson, 39° 19′ N. 118° 08′ W.; Inyo Mts. 7000-9000 ft.; Antelope Spr., 8 mi. SW. Deep Spr.) (April-August); *Kern Co.*, 5 ♀ (Arvin; Democrat Spr.; 6 mi. W. Inyokern, Short Canyon; Caliente) (March, June); *Kings Co.*, 2 ♀ (12 mi. SW. Avenal) (August); *Los Angeles Co.*, 13 ♂, 43 ♀ (Sta. Catalina Is.: Avalon, Cape Canyon, Pebbly Beach, Rancho Escondito; Newton; Clairmont; 5 mi. S. Pearblossum; Acton; Eagle Rock; Altadena; Whittier; 6 mi. W. Palmdale; Pasadina) (February-September, December); *Mariposa Co.*, 1 ♀ (1500 ft.) (May); *Mendocino Co.*, 1 ♀ (Ryan Cr.) (July); *Mono Co.*, 2 ♀ (Oasis) (May); *Monterey Co.*, 8 ♂, 15 ♀ (Paraiso Spr.; Jamesburg; Sta. Lucia Mts., Hastings Nat. Hist. Res. 1900-2700 ft.) (April-May, August-September, November); *Napa Co.*, 14 ♀ (Pope Valley; Mt. St. Helena; Conn Lake; Chiles) (March, May, September); *Orange Co.*, 3 ♀ (Newport Bay; Serra; Aliso Canyon nr. Laguna Beach; Laguna Beach) (July-August); *Riverside Co.*, 4 ♂, 32 ♀ (Palm

Spr.; Riverside; San Jacinto; San Jacinto Mts.: Idyllwild Keen Camp; 10 mi. W. Perris; Henshaw; The Gavilan; Whitewater; Corona; Palm Springs; Cathedral City; 2 mi. E. Anza; Elsinor; Murrieta; Andreas Canyon, Palm Spr.) (March-May, July, October); *San Bernardino Co.*, 1 ♂, 13 ♀ (Mill Cr.; Crestline; 5 mi. SE. Hesperia; 12 mi. SE. Ivanpah; E. Highlands; Morongo; Chino Canyon; Argus Range, Indian Joe Spr. 2600 ft.; Colton) (March-May, August-September); *San Diego Co.*, 3 ♂, 32 ♀ (Jacumba; Poway; Vista; Borego; 2 mi. N. Warner Spr.; 3 mi. S. Oak Grove; Barrett Spr.; El Cajon; San Diego; Campo; Descanso; Torry Pine Pk.; Warren) (March-April, July-September); *San Joaquin Co.*, 1 ♀ (Tracy) (July); *San Luis Obispo Co.*, 2 ♀ (Paso Robles; 2.5 mi. S. Creston) (April, September); *San Mateo Co.*, 1 ♀ (Jasper Ridge) (September); *Santa Barbara Co.*, 1 ♀ (Sta. Cruz Is.) (May); *Santa Clara Co.*, 2 ♂, 9 ♀ (Alum Rock Canyon; Stanford, Palo Alto; San Jose; Mt. Hamilton; Uvas Cr.) (July-August, October); *Sonoma Co.*, 5 ♀ (Guerneville; Preston) (May, July); *Stanislaus Co.*, 1 ♀ (del Puerto Canyon) (April); *Tulare Co.*, 1 ♂, 8 ♀ (Lindsay; Lemon Cove 500 ft.; 3-Rivers 600-800 ft.; Porterville; Kaweah) (June-July, November); *Tuolumne Co.*, 5 ♀ (Jamestown; 18 mi. SW. Sonora; 13 mi. SW. Sonora) (April, July); *Ventura Co.*, 54 ♀ (Quantal Canyon; 5 mi. S. Gorman, Hungary Valley) (May). NEVADA: *Douglas Co.*, 1 ♂, 1 ♀ (3 mi. S. Genoa) (August); *Washoe Co.*, 2 ♀ (Pyramid; Sutcliff) (June-July). NEW MEXICO: *Rio Arriba Co.*, 1 ♀ (Willow Creek) (August). UTAH: *Washington Co.*, 2 ♂, 66 ♀ (Zion Nat. Pk.; Toquerville; Leeds; St. George; Sta. Clara; La Verkin; Washington; Hurricane) (May-September).

BAJA CALIFORNIA: 16 ♀ (Cedros Is.: Bernstein Spr.; Isla Espíritu Santo; Coyote Cove, Conception Bay; Los Frailes; La Paz; 19 mi. E. Rosario; Canipol; 40 mi. S. El Arco Mine) (March, June, August, October). CHIAPAS: 1 ♀ (2 mi. N. Suchiapa) (July). GUERRERO: 19 ♂, 45 ♀ (17 mi. N. Chilpancingo 2250 ft.; Chilpancingo 3700 ft.; 5.2 mi. E. Chilpancingo 5700 ft.; 2 mi. S. Chilpancingo; 42 mi. N. Acapulco 1550 ft.; 9 mi. W. Acapulco; Acapulco; 42 mi. N. Acapulco 1550 ft.; Xalitla 1500 ft.) (March, August, December). MICHOACÁN: 1 ♂, 3 ♀ (11 mi. E. Apatzingan; 4 mi. E. Apatzingan; Apatzingan; 10 mi. N. Morelia 5900 ft.) (July-August). MORELOS: 1 ♂ (11 mi. S. Tlaltizapan) (August). NAYARIT: 2 ♂ (km. 78 Rte. 15) (September). OAXACA: 4 ♂, 6 ♀ (23 mi. S. Matías Romero 200 ft.; 4 mi. NW. Tehuantepec 700 ft.; 14 mi. NW. Tehuantepec 700 ft.; 6 mi. S. Tehuantepec 200 ft.; 10 mi. NE. Juchitán; 50 mi. N. La Ventosa) (June-July). SINALOA: 7 ♀ (6 mi. NE. Villa Unión 350 ft.; 3 mi. NW. Concha 50 ft.; 14 mi. SE. Elota; Los Moschis) (May, July). SONORA: 7 ♂, 18 ♀ (37 mi. N. Guaymas; 70 mi. N. Hermosillo; 4 mi. N. Guaymas;

Río Mayo; 20 mi. SE. Empalme) (April, September). YUCATÁN: 11 ♂, 1 ♀ (8 km. N. Muna; Mérida; Chichen Itza) (July). "San Carlos Bay" 1 ♀ (September); "San José de Guaymos" 4 ♂, 1 ♀ (April).

GUATEMALA: Retalhuleu, 2 ♀ (Champerico) (April).

COSTA RICA: Guanacaste, 3 ♂ (El Coco) (August).

A. pomoniella appears to be most abundant in California with smaller populations occurring from Baja California down the west coast of Mexico into Central America. Small and possibly isolated populations of *pomoniella* exist in Utah and possibly in New Mexico. The one specimen from New Mexico is without question *pomoniella* but does seem to be out of place. Whether this is due to mislabelling or to a lack of collecting cannot be determined from the available information. Specimens from the most southwestern county of Utah, Washington Co., are little different from those in California and seem to be a part of the main Californian stock. Specimens have been taken from near sea level to 7000 feet elevation in California and Arizona and from 200 to 6000 feet in Mexico. Specimens were found near sea level in Costa Rica.

The only species of *Augochlorella* with which *pomoniella* is in contact in the United States is *neglectula*, a species found chiefly on the Mexican Plateau and in the mountains of southern New Mexico and Arizona. Although the ranges of the two species broadly overlap in southern Arizona, they are apparently somewhat different ecologically, judging by random collections made in the Santa Catalina Mountains near Tucson, Arizona. These collections show *pomoniella* occurring from the Sonoran desert near Tucson, a saguaro-mesquite habitat at about 2800 feet near the base of the mountains, to about 5200 feet in oak-juniper association. *A. neglectula* has been collected at about 3800 feet and ranges well into the pines near the tops of the mountain at about 8100 feet elevation. *A. neglectula* has not been collected in the desert area around Tucson. This comparison is based only on the label data of 73 *pomoniella* and 64 *neglectula* from this one area.

Seasonal Activity. Females have been collected between February 28 and December 27 and males between May 3 and December 17, with little difference in dates throughout the range. Females were collected with pollen in their scopes from early March until the beginning of October in California, with similar dates being recorded from other areas as well. The wide variation in size (Fig. 84) is due to geographical differences rather than to seasonal or caste differences.

Flower Records. Acacia, Arctostaphylos, Argemone, Asclepias, Aster, Baileya, Bebbia, Brassica, Carnegia, Centaurea, Cercidium, Chrysothamnus, Cirsium, Cissus, Cleome, Cryptantha, Dalea, Encelia, Eriogonum, Eucnide, Fendlerella, Gossypium, Gutierrezia, Haplopappus, Helianthus, Heliotropi-

FIG. 85. Distribution of *A. pomoniella* (solid dots) and *bracteata* (rings).

um, Heterotheca, Hymenothrix, Isomeris, Kallstroemia, Melilotus, Oenothera, Opuntia, Penstemon, Peucephyllum, Rhus, Salix, Salvia, Senecio, Sisymbrium, Sphaeralcea, Tamarix.

Augochlorella neglectula neglectula (Cockerell)

Augochlora neglectula Cockerell, 1897, Bull. New Mexico Coll. Agr. Exper. Sta. 24:43 (descr.); Cockerell, 1898, Bull. Sci. Lab. Denison Univ. 11:47 (descr.); Cockerell, 1898, Zool. 2:80 (fl., distr.); Cockerell, 1899, Catalogo de las Abejas de Mexico p. 6 (list); Cockerell, 1899, Canad. Ent. 31:256 (fl., distr.); Cockerell 1900, Amer. Nat. 34:488 (fl., distr.); Cockerell, 1901, Ent. News 12:39 (fl.); Cockerell, 1902, Amer. Nat. 36:811 (fl.); Cockerell, 1903, Ann. Mag. Nat. Hist. (7)12:442 (descr.); Cockerell, 1906, Trans. Amer. Ent. Soc. 32:295

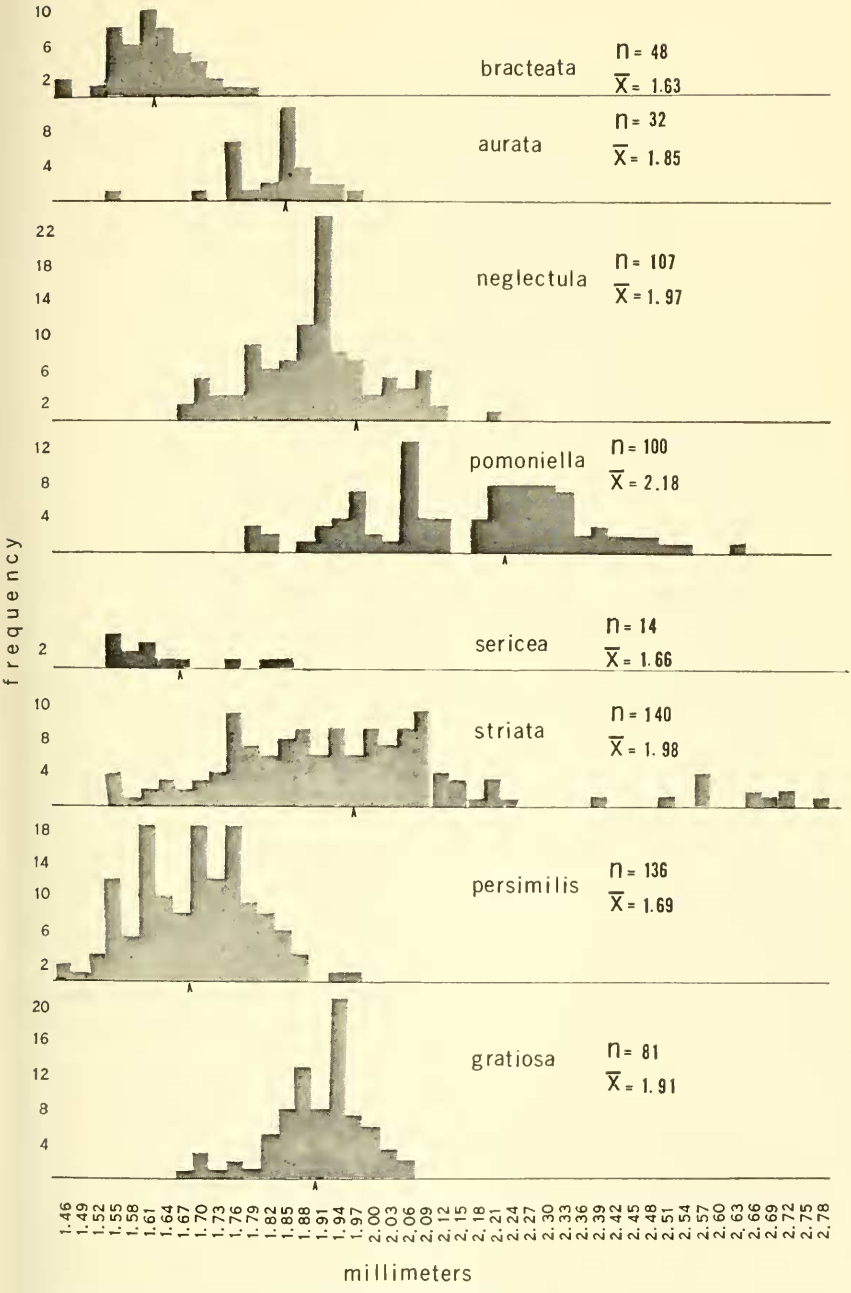


FIG. 86. Histograms showing head widths of field caught females throughout the range of each species, samples from throughout the season.

(distr.); Cockerell, 1915, Pomona Jour. Ent. Zool. 7:232 (descr.); Cockerell, 1927, Pan-Pacific Ent. 3:162 (descr.).

Augochlora dimissa Cockerell, 1923, Proc. U.S. Nat. Mus. 63:5 (descr.) (new synonymy).

Augochlora confusa: Cockerell, 1897, Bull. New Mexico Coll. Agr. Exp. Sta. 24:23, 25 (misidentification).

Augochlorella aurata: Sandhouse, 1937, Jour. Washington Acad. Sci. 27:71 (in part). (Since 1937, when Sandhouse erroneously synonymized *neglectula* with *aurata,* various authors have repeated this synonymy, but additional data pertaining to *neglectula* does not appear to have been given.)

Types. Augochlora neglectula, holotype male, from Filmore Canyon [Dona Ana Co.], New Mexico, August 29 (Townsend), in the collection of P. H. Timberlake, University of California at Riverside, California. Cotype (paratype) female, Filmore Canyon, New Mexico, August 24 (Townsend), No. 4345, in the collection of the U.S. National Museum. In 1906, Cockerell listed the type locality as Organ Mountains, New Mexico; probably Filmore Canyon is merely a more specific statement of the same locality. The species was recognized as new on the basis of male characters, and the holotype is well marked with "type" labels, although not in Cockerell's usual hand. *Augochlora dimissa*, holotype female, from Victoria [Tamaulipas], Mexico, March 16, is in the collection of the U.S. National Museum, No. 25582.

Description. Female: (1) Length 6 to 7 mm; head width 1.68 to 2.21 mm, averaging 1.97 mm; head usually wider than long. (2) Color bright green to dark blue; frons usually with blue reflections; metasoma often darker than head and thorax and suffused with brown. (3) Mandible with basal third dark brown, reddish brown centrally, rufous apically, without metallic reflections basally. (4) Clypeus slightly wider than long; basal half green with rather large punctures about a puncture width apart; apical half dark brown and slightly beveled, with about three to five large, often elongate punctures; surface between punctures smooth and shiny or finely reticulated at base and laterally. (5) Supraclypeal area irregularly punctate, sparsely so medially; surface between punctures usually shiny and smooth, sometimes minutely roughened and dull. (6) Paraocular area closely punctorugose below level of antennae, coarsely rugose above. (7) Antenna dark brown, flagellum slightly lighter below than above; pedicel as broad as long; first flagellar segment less than twice as wide as long. (8) Scutum with punctures variable in size and spacing, grading from distinctly and closely punctate to punctorugose, usually closer together laterally than medially; anterior margin finely roughened medially, becoming finely to coarsely rugose at anterolateral angles. (9) Tegula with length slightly greater than width, shiny, without conspicuous punctures. (10) Scutellum with small, close, irregular sized punctures, becoming indistinct in Mexican specimens. (11) Pleuron coarsely

rugose, areolate anteriorly. (12) Propodeum with disc usually less than 1.5 times as long as metanotum; outline of disc broadly semicircular, profile type 3, posterior edge abruptly rounded medially, becoming gradually rounded laterally; striae variable, usually regular, fine and radiating from medial area, medially extending about three-fourths length of disc and ending gradually, laterally nearly reaching edge or extending onto vertical surface; surface beyond striae dull and granular to edge; posterior and lateral vertical surfaces finely roughened, usually with fine horizontal rugae extending from lateral to posterior surface across rounded posterolateral corners. (13) Legs brown; fore and hind coxae with strong metallic reflections: fore femur sometimes weakly metallic. (14) First metasomal tergum with anterior surface polished, sparsely and finely punctate, dull to shiny dorsally, with fine, distinct, close punctures; second tergum with fine, close punctures, surface between punctures smooth, shiny to dull; first sternum with or without metallic reflections. (15) Pubescence white on head and ventrally on thorax and metasoma, white to pale golden or dorsal parts of thorax and metasoma and on legs, golden on thorax of most Mexican specimens.

Male: (1) Length 7 to 8 mm; head width 1.66 to 2.04 mm, averaging 1.85 mm, greater than, equal to or less than length. (2) Color bright green to blue, frons with bluish reflections in all specimens; usually variably blue-green over entire body. (3) Mandible with or without metallic reflections basally. (4) Clypeus with punctures large, widely spaced, surface between punctures minutely roughened to smooth and shiny. (5) Supraclypeal area variably punctate, surface between punctures smooth and shiny or sometimes minutely reticulate and dull. (6) Paraocular area closely punctate to finely rugose. (7) Flagellum dark brown above, yellowish brown below; scape and pedicel entirely dark brown or black; last one or two flagellar segments usually slightly darker below than preceding segments; pedical as broad as long; first flagellar segment about twice as wide as long. (8) Scutum shiny with punctures distinct, variably spaced medially to parapsidal lines, closer laterally; becoming weakly rugose at lateral anterior margin. (9) Tegula less than 1.5 times as long as wide, shiny, with punctures inconspicuous or lacking. (10) Scutellum shiny, distinctly punctate, more densely so posteromedially than elsewhere. (11) Pleuron areolate anteriorly and laterally. (12) Propodeum with disc slightly longer than, to 1.5 times as long as metanotum; outline of disc semicircular, posterior edge abruptly rounded; striae coarse, irregular, wavy, not reaching edge medially, extending onto vertical surface laterally; surface of disc beyond striae narrowly smooth and shiny or slightly roughened; posterior vertical surface shiny, finely roughened or rugose; posterolateral corners with lineate, horizontal rugae extending from lateral to posterior surfaces; lateral vertical surface finely rugose with horizontal lineate rugae anteriorly. (13) Legs brown, fore and hind coxae and trochanters with

strong metallic reflections; femora and fore tibia weakly metallic; middle and hind tibiae and all tarsi brown; hind basitarsus with straight, erect hairs of uniform length along entire segment; these hairs almost 1.5 times as long as width of segment; basal tuft reduced to inconspicuous. (14) Metasomal terga green with apical margins brown; first tergum polished with fine, widely scattered punctures anteriorly, smooth but less shiny dorsally with punctures small and close together; second tergum minutely to indistinctly punctate; sterna brown, occasionally suffused with black, pubescence short and fine, evenly distributed; first sternum with weak metallic reflections; second through sixth sterna with apical margins straight. (15) Pubescence white over entire body to golden in some Mexican specimens. (16) Genital capsule of type 4 (Figs. 37-38); inner lobe of gonostylus long and thin with blunt apex, bearing 3 to 5 stout setae; posterior edge of lobe with setae variable in size and number; setae on outer lobe (l₂ Fig. 27) usually branched; seventh tergum type 2 (Fig. 46); seventh and eighth sterna type 1 as figured (Fig. 40).

Comparisons. Most *neglectula* can be distinguished from all other North American species of *Augochlorella* by the fine radiating striae that extend only about three-quarters of the way across the propodeal disc, by the rugose nature of the posterior propodeal surface, by the blue areas on the frons, and by the shape of the inner lobe of the male gonostylus. In addition to these characters, it differs from *pomoniella* by the usually close, deep, often contiguous scutal punctures giving the scutum a rough or even rugose appearance. In *pomoniella* the scutum is smooth with distinct, widely spaced punctures. The legs, especially the trochanters and femora, are more uniformly brown in *neglectula* than in *pomoniella.* In most specimens there are no distinct posterolateral corners to the propodeum (Fig. 70) or if there are, they are weak. The corners are rarely polished and shiny as in *pomoniella* but usually are traversed by horizontal rugae extending from the lateral to posterior surfaces. This character will also distinguish *neglectula* from *striata* when the striae of the disc of *neglectula* become coarser and less strongly radiating than usual. Males can be easily distinguished from *striata* on the basis of the fourth sternum and genitalia.

A truer picture of the relationships of *neglectula* to the other North American species of *Augochlorella* must necessarily wait until a study is made of the Mexican, Central and South American species of the genus with which it is possibly more closely related. It has no close affinities with *Pereirapis* and among the species from the United States is most similar to *pomoniella. A. neglectula* and *pomoniella* may look similar in areas where their ranges overlap but there is no evidence of genic exchange since the features of each species are maintained. There is a similar resemblance in a

few individuals to *striata* but in all such cases also, *neglectula* maintains its identity.

Variation. Populations of *neglectula* in Arizona show the greatest amount of variation, particularly in the degree of thoracic roughness. Females are more variable than males.

There is not much difference in size among individuals from different areas of the range although the mean head width of females is largest in Mexico (1.99 mm) and smallest in Texas (1.85 mm). The width of the head is less variable in males, but no trends can be described due to the meager samples available from most areas.

The supraclypeal area is shiny in most males and females from the United States but is rarely polished or brilliant. It may be entirely punctate or, more frequently, sparsely punctate medially, more densely so laterally. In many of the Mexican females, as in some Mexican *pomoniella*, the supraclypeal area is dull due to minute reticulations on the integumental surface. This dullness extends onto the basal area of the clypeus and over the scutum, and the brown color on the apex of the clypeus extends in a narrow medial line to the base of the clypeus. In no case is the clypeus entirely brown. But unlike *pomoniella*, other less dull or even shiny *neglectula* sometimes show this same variation of clypeal coloration. The dull specimens may be found throughout the range of Mexican *neglectula* from March to September. The supraclypeal area of the males is rarely dull even though it may be coarsely punctured. The minute fine reticulations were found on only three out of 42 males from Arizona (from Yuma, Cochise and Pima Counties) and on four out of 18 Mexican individuals (from Chihuahua, San Luis Potosí, Durango and Guerrero). Although the roughening may extend onto the clypeus, it does not appear on the scutum and the dullness is considerably less striking than on the females. The female holotype of *Augochlora dimissa* from Victoria, Mexico, shows this dull condition although in every other respect appears to be a normal Mexican *neglectula*. Since there is no apparent morphological difference associated with this condition and no geographical pattern or even distinct population of dull individuals, there is no basis for recognizing this variant either as a species or subspecies.

Although the blue patch on the frons is characteristic of this species, in many Mexican females the blue area is obscure and can only be found with difficulty. It is not found at all in the Mexican subspecies *maritima*.

The punctures of the scutum are distinct with their diameters about equal to the spaces between them in about half the males (40 specimens) from all parts of the range, but are close, deep, and contiguous or form a rugose surface in the other half (37 specimens). The scutum is coarsely and closely punctured in females (except for six females from Arizona which have the punctures more widely spaced).

There is considerable variation in the nature of the propodeal area, especially in specimens from Arizona. In the females, the Mexican specimens show the typical *neglectula* pattern with fine, straight, radiating striae on the disc, often reaching the posterior medial edge of the disc. The horizontal rugae are rarely present on the posterior and lateral surfaces of the propodeum but these surfaces are rough and dull. When the striae are larger or less fine the rugae are present posterolaterally. "Typical" *neglectula* are also found in Arizona but individuals occasionally may resemble either *pomoniella* or *striata*. Those similar to *pomoniella* [10 out of 57 specimens from the Santa Catalina Mts. (1*), and two out of five specimens from Globe (9)] have short striae that are finer than found on the usual *pomoniella*. The posterolateral corners are weak and the edge of the disc is shinier than usual, but the polished surface does not extend onto the vertical sides. All these specimens have horizontal rugae on the posterior surface. Those that resemble *striata* have coarser striae than normal, often reaching almost to the posterior margin of the disc, but in all cases the vertical surfaces are rough with well defined horizontal rugae. Such specimens were found commonly in New Mexico and Texas although the rugae are often less distinct in Texan specimens. None of the specimens from New Mexico or Texas resembles *pomoniella*.

In males, the striae of the disc are variable in thickness but generally rather coarse. In 10 of the 42 males from Arizona and 3 of the 18 Mexican males (Zacatecas, Chihuahua and "Guadalupe"), the propodeum resembled that of *pomoniella*, having shiny, smooth posterolateral corners and smoother vertical surfaces than is normal for *neglectula*, with the horizontal rugae indistinct or absent. Punctures on the propodeum were distinct although close and coarse so that the roughened character of *neglectula* is maintained in these specimens.

The inner lobe of the gonostylus of the male genitalia is rather constant in shape but variable in the number and character of the setae it bears on its outer edge. These setae may number two or three and be short, very thin and flaccid (Fig. 37), but may vary to long, thick, heavily sclerotized and up to 14 in number. When the larger number are present the series is continuous with the setae at the apex of the lobe, with one or two weaker setae between those on the posterior and apical margins (Fig. 39). If the setae are weak, there is usually a space between those of the two series (Fig. 38). As the setae become longer and thicker the lobe itself becomes shorter and broader. All intermediate conditions occur between the two extremes, and all forms apparently occur throughout the range. No correlation has been found between these genitalic differences and external morphological varia-

* See Table 1.

tion. In no case does the inner lobe look similar to that of any other species here considered.

The outer lobe of the gonostylus bears long, fine, branched or unbranched setae. Branched hairs cannot be correlated with either locality or external morphological variation.

The Guatemalan and Panamian specimens look like those from Mexico.

Distribution. From the southern half of Arizona and southwestern New Mexico into the Big Bend area of Texas, southward through all of central Mexico, with specimens also from Guatemala and Panama (Map: Fig. 87).

A total of 79 males and 279 females have been seen: ARIZONA: *Apache Co.*, 1 ♀ (White Mts.) (June); *Cochise Co.*, 7 ♂, 23 ♀ (Huachuca Mts., Ramsey Canyon; Chiricahua Mts.: SW. Res. Sta. 5400 ft., Rustlers Park 8784 ft., Portal 5000 ft.; Douglas; 6 mi. NE. Douglas) (March-August); *Coconino Co.*, 1 ♀ (Oak Creek Canyon 3500 ft.) (August); *Gila Co.*, 7 ♀ (Bot Fly Canyon, Pinal Mts. 3500 ft.; Globe; Payson) (May, July, September); *Graham Co.*, 3 ♂, 2 ♀ (Graham Mts.: 6000-7000 ft., Wet Canyon) (July); *Maricopa Co.*, 1 ♀ (Reef); *Navajo Co.*, 1 ♀ (Carrizo Cr.) (June); *Pima Co.*, 24 ♂, 72 ♀ (Santa Catalina Mts.: mile posts Nos. 9, 10, 23 Hitchcock Highway, Pepper & Sauce Canyon, Sabino Canyon, Sabino Basin ca. 3800 ft., Ventana Canyon, Catalina Springs, Molino Basin; Santa Rita Mts. 4000-8000 ft.; Baboquivari Mts.: Kits Peak Rincon ca. 1050 ft., Brown's Canyon) (February, April-November); *Pinal Co.*, 1 ♂, 1 ♀ (Superior) (February, July); *Santa Cruz Co.*, 2 ♂, 5 ♀ (Ruby, Sycamore Canyon; Patagonia; 17 mi. W. Nogales) (March-May, August, November); *Yavapai Co.*, 1 ♀ (4 mi. S. Jerome) (July); *Yuma Co.*, 5 ♂, 1 ♀ (Parker Creek; Sierra Ancha Exper. Sta.) (May, August). NEW MEXICO: *Catron Co.*, 1 ♀ (Mogollon Mts.) (August); *Dona Ana Co.*, 2 ♂, 28 ♀ (Las Cruces; Organ Mts.: La Cueva ca. 5300 ft., 5100 ft., Riley's Ranch, Filmore Canyon 5700 ft., Dripping Springs) (April, June, August-September); *Grant Co.*, 2 ♂, 1 ♀ (6 mi. N. Silver City; 14 mi. N. Silver City; Pinos Altos) (June-July); *Otero Co.*, 1 ♀ (Alamogordo) (May). TEXAS: *Brewster Co.*, 1 ♂, 6 ♀ (65 mi. S. Marathon; Basin 5000 ft., Big Bend Nat. Pk.; Chisos Mts.) (June-July); *Jeff Davis Co.*, 11 ♂, 7 ♀ (Davis Mts.; Ft. Davis; 23 mi. W. Ft. Davis) (April-July); *Val Verde Co.*, 1 ♂, 6 ♀ (Devil's River) (May).

CHIHUAHUA: 5 ♂, 4 ♀ (92 km. N. Chihuahua; 80 km. N. Chihuahua; Terrero 5500 ft.; Valle de Olivos 5500 ft.) (May-July). DURANGO: 1 ♂, 5 ♀ (12 mi. N. Alamillo; Nombre de Diós; El Tascate 6400 ft.; 69 mi. N. Durango, Hwy. 31; 12 mi. W. Durango) (February, June-July). GUERRERO: 7 ♀ (2 mi. S. Chilpancingo; 5.2 mi. E. Chilpancingo 5700 ft.; 5 mi. S., 2 mi. E. Chilpancingo 3800 ft.; Chilpancingo 4000 ft., 3700 ft.) (August). HIDALGO: 1 ♂, 21 ♀ (23 mi. NE. Jacala 5075 ft.; 38 mi. NE. Jacala 3100 ft.; Zimapan; 6 mi. E. Tulancingo; 4-5 mi. W. Pachuca) (June-Septem-

ber). JALISCO: 5 ♀ (22 mi. NW. La Piedad; 15.5 mi. NE. Lagos de Moreno 6200 ft.; 6 mi. SE. Lagos de Moreno 5900 ft.) (July). MEXICO: 3 ♀ (Teotihuacan Pyramid; Valle de Bravo 6500 ft.) (June, August). MICHOACÁN: 1 ♂, 3 ♀ (Quiroga 6300 ft.; Morelia) (February, July). MORELOS: 1 ♂, 5 ♀ (Cuernavaca 5500 ft.; 5 mi. S. Cuernavaca 4000 ft.; 3 mi. W. Cuernavaca 6500 ft.; Yautepec 4000 ft.) (March-May). NUEVO LEÓN: 1 ♂, 7 ♀ (4 mi. W. El Cercado 2100 ft.; 12 mi. S. Linares; China) (June, August, December). OAXACA: 3 ♂, 6 ♀ (7 mi. SE. El Camerón; Tehuantepec; 5 mi. E. Oaxaca; 10 mi. NE. Oaxaca; Oaxaca; 23 mi. NE. Nochixtlán 7000 ft.; 12 mi. SE. Nochixtlán 7100 ft.) (April, June, July, December). PUEBLA: 3 ♀ (2 mi. NW. Petlalcingo 4600 ft.; 8 mi. SE. Tehuitzingo 4100 ft.; 13 mi. E. Villa Juárez 1300 ft.) (June). QUERETARO: 3 ♀ (Queretaro) (June). SAN LUIS POTOSÍ: 2 ♂, 30 ♀ (El Salto 1500-1800 ft.; 5 mi. E. Ciudad Maiz 4700 ft.; 3.4 mi. NE. El Naranjo 800 ft.; 5 mi. W. Xilitla; 14 mi. W. Xilitla 4200 ft.; 8 mi. W. Xilitla 3500 ft.; 4.3 mi. NW. Nuevo Morelos; El Huizache; 10 mi. NE. San Luis Potosí 6200 ft.; 29 mi. SW. San Luis Potosí 6800 ft.) (June-September). TAMAULIPAS: 2 ♀ (Llera, Victoria) (March, June). TLAXCALA: 1 ♀ (8 mi. W. Apizaco 8500 ft.) (June). VERACRUZ: 3 ♀ (4 mi. NW. Rinconada Antigua 1350 ft.) (June). ZACATECAS: 1 ♂, 4 ♀ (15 km. E. Sombrerete; 2 mi. S. Fresnillo; 9 mi. S. Fresnillo; Fresnillo 7000 ft.) (July-August).

GUATEMALA. Alta Verapaz, 1 ♀ (Trece Aguas).

PANAMA. Canal Zone, 1 ♂ (Fort Clayton) (May).

This species is widespread in the central plateau area of Mexico. The range extends northward through the Chihuahua desert to New Mexico and Arizona. It also extends southward at least as far as Panama. *Augochlorella n. neglectula* is not known from along the coasts of Mexico, although it approaches them in Oaxaca and Veracruz. It has been taken at elevations from 800 to 8500 feet in Mexico and from 1050 to 8100 feet in Arizona and New Mexico. (See also discussion under *pomoniella*.)

Titus (1901) reported two female specimens of *neglectula* from Ft. Collins and Greeley, Colorado. One specimen from each locality (8) with dates matching those given by Titus has been examined but both specimens were normal Colorado *striata* D. All other specimens examined from Colorado have also been *A. striata* and therefore it is assumed that Titus was mistaken in his identification and that *neglectula* extends only as far north as Catron Co., New Mexico, and Yavapai Co., Arizona.

Dreisbach (1945) reports *neglectula* from Michigan, but this is clearly a case of confusion in synonymy. (See distribution of *persimilis*.)

Seasonal Activity. Females have been collected from mid-February to the end of November in Arizona and to the end of December in Mexico. Males have been taken from March through November in the United States

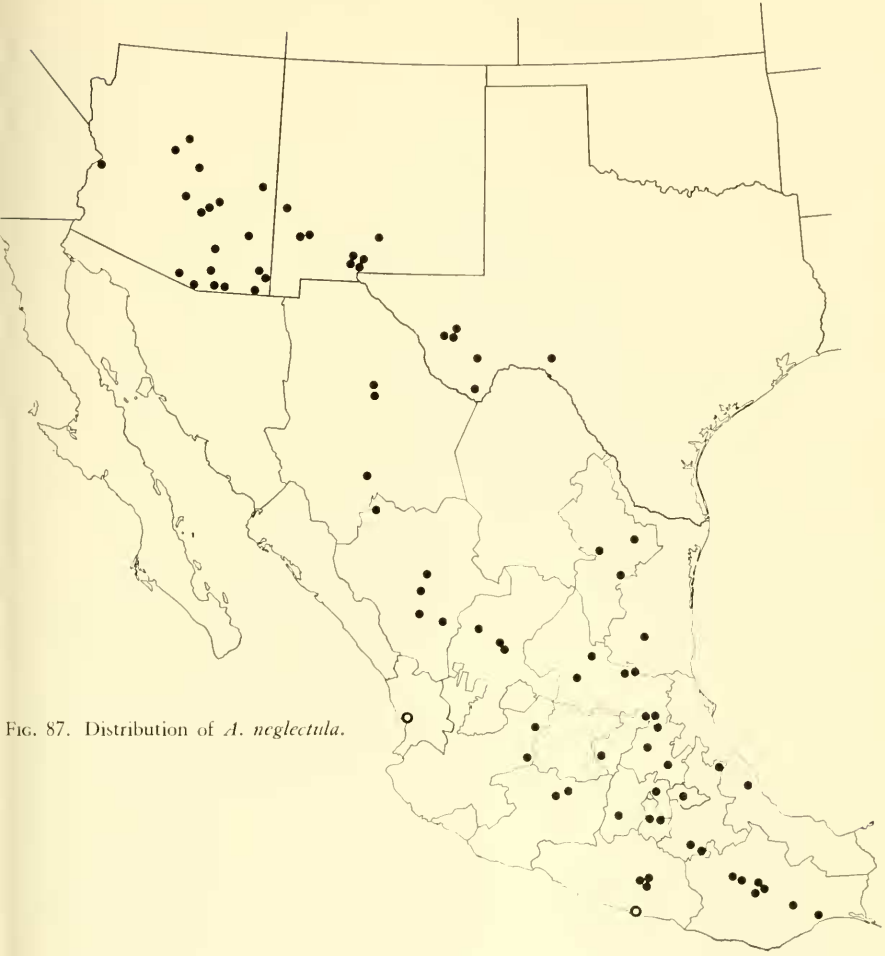


Fig. 87. Distribution of *A. neglectula.*

and all through the year in Mexico. Females with pollen in their scopas were collected from April through August in the United States and from February through December in Mexico.

It seems probable that there is little or no activity during December and January in the United States and that nesting takes place from the middle of April into September or October, depending on the elevation. In Mexico, the bees are apparently active and nesting throughout the year, at least at the lower elevations.

Flower Records. Acacia, Aesculus, Baccharis, Ceanothus, Chilopsis, Chrysanthemum, Chrysopsis, Dalea, Descurainia, Echinocactus, Erigeron, Eschscholtzia, Fendlera, Gaillardia, Gossypium, Gutierrezia, Helenium, Heterotheca, Lepidium, Manzanita, Melilotus, Opuntia, Penstemon, Prunus, Pyrus, Rosa, Senecio, Sida, Sisymbrium, Sphaeralcea, Ungnadia.

Augochlorella neglectula maritima new subspecies

Types. 22 males, 30 females (holotype male, allotype female and paratypes), 20 mi. E. Acapulco, Guerrero, Mexico, August 12, 1962 (Univ. Kansas Mexican Exped.). Additional paratypes as follows: MEXICO. Guerrero: 3 females, 5 males, 20 mi. E. Acapulco, 11 August 1962 (Univ. Kansas Mexican Exped.); 1 female, 20 mi. E. Acapulco, 11 August 1962 on *Microspermum nummulariaefolium* (E. Ordway); 6 females, Acapulco, 6 August 1954 (Univ. Kansas Mexican Exped.); Nayarit: 1 male, San Blas, 13 September 1957 (R. & K. Dreisbach).

Holotype, allotype and 31 female and 19 male paratypes are in the Snow Entomological Museum, The University of Kansas. Two female and two male paratypes are in each of the following collections: Michigan State University, American Museum of Natural History, U.S. National Museum and the California Academy of Sciences.

Description. This subspecies, known only from the Pacific Coast of Mexico, differs from the true *neglectula* only as follows:

Female: (1) Length of head greater than width (width 1.66 to 1.96 mm, averaging 1.81 mm). (2) Frons without bluish reflections. (3) Mandible with basal half brown. (4) Clypeus as long as broad with apical third brown. (8) Scutum finely and very closely punctured, punctures becoming indistinct on extreme anterolateral angles. (9) Tegula oblong, twice as long as wide; surface coarsely punctate and dull on dark brown area. (12) Edge of propodeal disc more angulate than in typical *neglectula*. (13) Legs dark brown with weak greenish reflections usually on fore and hind coxae, fore trochanter, fore and middle femora and fore tibia.

Male: (1) Length of head greater than width (width 1.52 to 1.84 mm, averaging 1.70 mm). (2) Color bright green, metasoma suffused with black; frons without bluish reflections. (7) Antenna with first flagellar segment entirely dark brown. (9) Tegula oblong, more than twice as long as wide, with distinct, close punctures on dark brown area; surface dull. (11) Pleuron coarsely punctured, becoming rugose laterally. (16) Genital capsule with inner lobe of gonostylus heavily sclerotized with straight outer edge and thick, coarse, long bristles to apex, without gap or finer bristles separating outer and apical series of setae (Fig. 39).

Comparisons. A. n. maritima looks similar to *neglectula* but can be readily distinguished by the size, shape, punctations and dullness of the tegulae. In addition, it lacks the blue areas on the frons and is less rugose on the face, thorax and posterior surface of the propodeum. The general appearance of the propodeum is smoother than in *n. neglectula* but otherwise little different. The first flagellar segment of the male is entirely dark in *maritima* and the inner lobe of the gonostylus of the male genitalia is more heavily

sclerotized and bears stronger setae than most *n. neglectula*, although intergradations exist. The oculo-ocellar ratios show that the top of the head is slightly narrower than that of *neglectula* and the head is longer in relation to the width. The overall impression is of a longer head with the eyes narrower and less emarginate, and the clypeus longer than in *n. neglectula*. The habitat of *maritima* appears to be distinct from that of *n. neglectula*; the former has so far only been found on the sand dune areas along beaches of the west coast of Mexico (circles, Fig. 87).

Augochlorella edentata Michener

Augochlorella edentata Michener, 1954, Bull. Amer. Mus. Nat. Hist. 104:58-59 (descr.).

Types. Holotype female, from Panamá, Coclé Province, El Valle de Antón, April 1, 1945 (Michener), is in the American Museum of Natural History. One female paratype each: type locality, January, 1947 (Krauss), at The University of Kansas; Canal Zone, Summit, November, 1946 (Krauss); Balboa, May 25, 1914, in shady jungle (Hallinan).

Description. Female: (1) Length 6 to 7 mm; head width 1.55 to 1.87 mm, averaging 1.66 mm, width greater than length. (2) Color yellow-green to dark green with silky sheen or luster; frons without blue reflections; metasoma usually similar in color to head and thorax. (3) Mandible dark brown, becoming yellow-brown just before rufous tip, without greenish reflections at base. (4) Clypeus about as long as wide, almost flat; basal half green with distinct but shallow punctures, widely but uniformly spaced, usually finely and closely punctured or roughened along basal suture; apical half brown, very slightly beveled, with elongate, shallow, groove-like punctures separated by about their own diameters; surface between punctures shiny and smooth. (5) Face broadly convex from apex of clypeus to vertex; supraclypeal area flat to weakly rounded, smooth and shiny to minutely roughened with or without punctures. (6) Paraocular area finely and uniformly roughened throughout by widely scattered minute granules. (7) Antenna dark brown, becoming yellow-brown at tip; last flagellar segment entirely yellow-brown; flagellum lighter below than above; pedicel width subequal to length, first flagellar segment almost twice as wide as long; pedicel longer than and about as wide as first flagellar segment. (8) Scutum without distinct punctures, surface finely and irregularly roughened throughout (Fig. 79); anterior margin smooth medially to anterolateral angles, except for minute reticulations on surface. (9) Tegula about 1.33 times as long as wide. (10) Scutellum finely and irregularly roughened, without punctures. (11) Pleuron finely rugose, weakly areolate anteriorly. (12) Propodeum with disc almost twice as long as metanotum; outline of disc semicircular to broadly

U-shaped, profile type 4; posterior edge of disc smoothly and gradually rounded medially and laterally; striae fine and close, irregular and branching medially, straight and distinct laterally, occupying basal half to two-thirds of disc medially, sometimes attaining edge laterally; area beyond striae minutely reticulated; horizontal area of propodeum only partially occupied by disc laterally and at posterolateral corners; posterior vertical surface exceedingly finely and evenly granular in larger specimens, smooth and shiny with widely spaced minute punctures in smaller specimens; posterolateral corners finely roughened to nearly smooth; lateral vertical surface weakly roughened. (13) Legs brown with slight metallic reflections on hind coxa only. (14) Metasomal terga dark green to golden-green, suffused with brownish in some specimens; first tergum with anterior surface polished with widely scattered punctures laterally; dorsal surface with minute punctures evenly spaced; second tergum with minute punctures, more crowded than on first; first sternum without metallic reflections. (15) Pubescence white to golden-white dorsally on head and thorax, dorsally and ventrally on metasoma; white ventrally on head, thorax and basal parts of legs; golden on tibiae and tarsi.

Male: (1) Length 6 mm; head width 1.48 to 1.63 mm, averaging 1.56 mm, width slightly greater than length. (2) Color olive-green with yellow-green sheen, varying to yellow-green with golden sheen in some specimens; frons without bluish reflections; metasoma dark brown. (3) Mandible yellow-brown, only slightly rufous at tip, basal condyles usually dark brown; basal metallic reflections absent. (4) Clypeus with punctures shallow and widely spaced, sometimes closer basally; surface between punctures brightly polished. (5) Face broadly convex from apex of clypeus to vertex; supraclypeal area scarcely protuberant, impunctate but variably roughened. (6) Paraocular area smooth and polished below level of antenna with a few, widely spaced, minute punctures, becoming rougher toward frons; frons with dense mat of short white pubescence extending from antennal sockets to vertex. (7) Flagellum slightly darker above than below; scape and pedicel dark brown; last one and a half to two flagellar segments uniformly dark brown; pedicel and first segment each less than twice as wide as long. (8) Scutum shiny with satiny luster; punctures very weak, sparse and widely spaced (wider than own diameters), minute centrally, larger and closer laterally, becoming slightly deeper and contiguous to weakly and finely punctorugose anterolaterally; anterior margin smoothest medially, becoming rougher laterally; sculpturing exceedingly fine, shallow and indistinct (Fig. 79). (9) Tegula twice as long as wide. (10) Scutellum shiny, slightly roughened and punctate, punctures weak and widely spaced. (11) Pleuron shallowly and irregularly punctorugose, shallowly areolate anteriorly; surface between impression minutely roughened, dull. (12) Propodeum with disc

about 1.75 times as long as metanotum; outline of disc U-shaped, posterior edge indistinct, smoothly and gradually rounded and shiny; striae distinct, fine, close, irregular, often branched, extending about three-fourths length of disc medially, reaching edge laterally; surface of disc beyond striae smooth, minutely reticulated, irregularly and minutely wrinkled; posterior vertical surface of propodeum and posterolateral corners shiny and smooth with widely spaced, minute punctures; lateral vertical surface of propodeum finely but regularly roughened becoming distinctly but shallowly punctate dorsally. (13) Legs dark brown; fore and hind coxae and femora with slight greenish reflections; tibiae and tarsi lighter brown at bases; hind basitarsus with erect hairs short, uniform in length, dense, slightly longer than width of segment; basal tuft indistinct. (14) Metasomal terga dark brown with slight bluish highlights and broad, reddish brown apical margins; first tergum polished anteriorly, with slight olive-green metallic reflections, smooth but less shiny dorsally, sparsely and minutely punctate; second and following terga smooth, dull, essentially impunctate but with widely scattered minute punctures; all sterna brown, finely and uniformly pubescent, without metallic reflections, with apical margins straight; surfaces smooth without reticulations or punctures. (15) Pubescence golden dorsally, white ventrally; face with mat of short, dense, white hair from antennae to vertex and longer, fine, golden hair dispersed over entire face; pubescence golden dorsally on thorax, entire metasoma and legs, white ventrally on head and thorax. (16) Genital capsule, seventh and eighth sterna and eighth tergum type 3 (Figs. 36, 42, 47).

Comparisons. This species has certain affinities with both the species of the north and those of the *Pereirapis* group. It is small, has the convex face and the similar fine, smooth sculpturing and discal shape, and has the straight margin of the fourth sternum in the male, all as in *Pereirapis.* But the genital capsule and the white apex of the clypeus of the male are more similar to those of the North American species than to *Pereirapis. A. edentata* is characterized by its round, convex face (Fig. 55), comparatively smooth, fine and very shallow body sculpturing, and usually by the yellow tipped antennae in the female. The clypeus is also flatter than in other North American species but comparative material is necessary to recognize this character.

Variation. The body color in both males and females varies from dark green to yellow-green. Although the bee is shiny, the color is dull, with olive-green tones. In females, the metasoma is green or only slightly suffused with brown in some of the darker specimens, or yellower green in lighter colored individuals. The metasoma is consistently brown in males.

There is greater variation of the head width to length ratio in females than

in males. (However, the available males are nearly all from the same population.) Both the length and width are variable in females.

The clypeal punctures are generally rather uniform in males but variable in size, number and spacing in females. The basal punctures range from absent to crowded in both sexes.

The tips of the antennae of females are brownish yellow in all specimens examined from Mexico and Costa Rica, the intensity of the yellow varying only slightly. However, in the holotype the antennal tips are brown, only inconspicuously paler than the rest of the flagellum. The one paratype seen, also from the type locality, has the antennal tips yellower than the holotype but darker than those from Mexico and Costa Rica. More specimens should be examined to see if this is individual or geographical variation.

There is slight variation in the quality of the roughening of the scutum among females. On about half the specimens the smoothness of the anteromedial edge extends down each side of the median suture, creating a transverse gradient in degree of roughness from the center line to the parapsidal lines. However, the anterolateral angles are no more roughened than other parts of the scutum in either sex.

The punctures on the scutellum are variable in size, number, spacing and depth among males.

There is little variation in the propodeal area of males, but in females the length of the striae is variable, extending more than two-thirds the length of the disc in only one specimen ["Rin Antonio" (9*)]. In this specimen, only a small area is unstriated medially, and the lateral striae are strong, ending abruptly at the edge. Although lateral striae usually reach the edge, they my be shorter in the larger specimens. The sloping horizontal area of the propodeum is usually only partially occupied by the disc laterally, the rest of the horizontal area being characterized by sculpturing similar to that of the vertical surface (Fig. 67). The posterior vertical surface in females varies from very smooth, broken only by widely scattered minute punctures, to weakly uneven or slightly roughened. There is also some variation in amount of roughening of posterolateral angles. There is little variation in the lateral vertical surface.

The metasomal punctures are similar in all specimens; however, in females they may vary somewhat in depth and are barely detectable in some individuals.

The color of the pubescence is difficult to determine in most specimens of both sexes, usually because of wear or dirt. Some appear lighter than others so that the dorsal pubescence appears to range from all white to golden. The short, dense facial pubescence is matted and gummy in most specimens, giv-

* See Table 1.

ing the face a yellowish cast. This facial hair is worn away on some specimens.

Distribution. This species has been taken only as far north as southern San Luis Potosí in Mexico. It ranges at least as far south as Panama and has been taken at elevations from 200 to 4500 feet (Map: Fig. 88).

The following specimens have been seen: MEXICO. MORELOS: 1 ♂, 2 ♀ (3 mi. N. Alpuyeca 3400 ft.; S. end Cuernavaca 4500 ft.) (March-April); OAXACA: 1 ♀ (Rin Antonio); SAN LUIS POTOSÍ: 12 ♂, 4 ♀ (Huichihuayan; Xilitla 1450 ft.; 5 mi. E. Xilitla) (July, September); VERACRUZ: 1 ♂, 6 ♀ (17 mi. NW. San Andrés Tuxtla 900 ft.; 6 mi. N. Jesús Carranza, Isthmus of Tehuantepec 200 ft.; 1.4 mi. N. Santiago Tuxtla 1150 ft.; Córdoba) (January, June).

GUATEMALA. ALTA VERAPAZ, 2 ♀ (Trece Aguas) (June).

Fig. 88. Distribution of *A. aurata* (solid dots) and *edentata* (rings).

EL SALVADOR. LA LIBERTAD, 6 ♀ (5 mi. W. Quezaltepeque) (June-August).

COSTA RICA. CARTAGO: 3 ♂, 1 ♀ (Turrialba) (August); LIMÓN: 2 ♂, 12 ♀ (Pandora) (August); PUNTARENAS: 1 ♂, 14 ♀ (6 mi. NE. Esparta; Gromaco 34 km. SE. Potrero Grande, Río Coto Brus 1000 ft.; Playón, 8 mi. N. Parrita 30 m) (June-July, December); SAN JOSÉ: 2 ♂, 5 ♀ (Pozo Azul, junc. Ríos Parrita and Candelaria 85 m) (August).

PANAMÁ. See localities for type material above.

Seasonal Activity. Females of *edentata* are apparently active throughout the year; males have been collected from March through August but are probably active in other months as well. Pollen collectors have been found during June and July in Mexico and in August and December (1 specimen) in Costa Rica.

Augochlorella bracteata new species

Augochlorella aurata: Sandhouse, 1937, Jour. Washington Acad. Sci. 27:70 (in part) (taxon.).

Types. Holotype female, Southmost, Cameron Co., Texas, March 27, 1951 (R. H. Beamer) taken on *Prosopis*; allotype male, same locality, April 13, 1950 (Beamer, Stephen, Michener, Rozen); 45 female paratypes, same locality, March 27, 1951 (Beamer); 26 female paratypes, same locality and date (Michener); 4 male paratypes, Brownsville, Texas, June; 2 male paratypes, Cameron Co., Texas, August 3, 1928 (J. G. Shaw); 1 male paratype, Brownsville, Texas, April 17, 1952 (Michener, Beamer, Wille, LaBerge).

Holotype, allotype, 55 female and 3 male paratypes are in the Snow Entomological Museum of The University of Kansas; one male and four female paratypes are in each of the following: the American Museum of Natural History, the U.S. National Museum, the University of Nebraska and the California Academy of Sciences. I have seen 14 males and 137 females from other localities in Texas and Mexico, not included in the type series. The holotype and female paratypes represent a series of large and uniformly similar bees, probably spring queens. Not included in this series are smaller and more morphologically diverse specimens, including probable worker-like individuals.

Description. Female: (1) Length 5 to 6 mm; head with 1.47 to 1.79 mm (holotype=1.79 mm), averaging 1.63 m, width equal to, or slightly greater than length. (2) Color yellow-green to dark green (bright green in holotype); frons without bluish reflection; metasoma often slightly browner than rest of body. (3) Mandible with basal third dark brown, yellowish brown centrally, rufous at tip, without green basal reflections. (4) Clypeal width

equal to or subequal to length (length slightly greater than width in holotype), basal two-thirds green, punctures variable, irregularly spaced, smaller basally than apically; apical third brown and slightly beveled with large, deep punctures; surface between punctures shiny and smooth. (5) Supraclypeal area sparsely punctured medially, becoming densely punctured peripherally; surface smooth to minutely reticulated. (6) Paraocular area with large contiguous punctures below antenna, finely rugose above antenna. (7) Antenna dark brown; flagellum usually lighter below than above; pedicel longer than wide; first flagellar segment slightly wider than long; pedicel longer and narrower than first segment. (8) Scutum smooth, finely and uniformly punctured throughout, punctures small, close, distinct, extending almost to anterior edge; anterior edge with surface slightly roughened medially as on vertex becoming slightly rougher laterally to very finely rugose at anterolateral angles. (9) Tegula 1.5 to 2.0 times as long as wide. (10) Scutellum rough with fine, shallow, irregular to indistinct punctures. (11) Pleuron punctorugose to shallowly and finely rugose (finely punctorugose in holotype), areolate anteriorly. (12) Propodeum with disc equal to or slightly longer or shorter than metanotum (slightly longer in holotype); outline of disc semicircular, profile type 2, posterior edge of disc abruptly rounded, indistinct, more gradually rounded laterally; striae irregular, vermiform or straight (rather straight in holotype), fine and close together, usually ending almost at edge of disc medially, straight and reaching edge but not crossing it laterally; surface at ends of striae minutely roughened, narrowly shiny; posterior vertical surface and posterolateral corners shiny but surface uneven, without punctures or coarse roughening, often weakly granular posteriorly and finely granular at posterolateral corners; lateral surface moderately roughened to weakly rugose (weakly rugose in holotype), without basal subhorizontal rugae. (13) Legs brown, fore and hind coxae with strong green reflections, femora and hind trochanter with weak metallic reflections. (14) Metasomal terga green, suffused with brownish; apical margins narrowly pale brown; first tergum shiny, polished, with numerous, fine, distinct punctures anteriorly, almost impunctate along narrow median longitudinal area, smooth and shiny dorsally with numerous, small, close, distinct, regularly spaced punctures; second tergum with punctures more numerous and smaller; first sternum without metallic reflections. (15) Pubescence golden-white dorsally, white ventrally on head, thorax and basal parts of legs, golden on leg extremities and ventral part of metasoma.

Male: (1) Length 5 to 6 mm; head width 1.53 to 1.76 mm, averaging 1.63 mm, width less than, equal to, or greater than length (width equal to length in allotype). (2) Color yellowish green to dark green; frons without bluish reflections; metasoma variably suffused with brownish. (3) Mandible without metallic reflections basally. (4) Clypeus with punctures large medially,

small and close basally and laterally; surface between punctures usually smooth and shiny. (5) Supraclypeal area finely punctate laterally; surface shiny basally, usually minutely roughened above. (6) Paraocular area finely and weakly rugosopunctate. (7) Antenna dark brown above, dark yellow below; scape usually narrowly yellow below; last flagellar segment entirely pale brown to dark brown, pedicel and first flagellar segment each less than 1.5 times as wide as long. (8) Scutum shiny and smooth with punctures small, distinct, usually separated by at least the width of a puncture medially, closer laterally and anteromedially; anterior margin weakly roughened as on vertex, becoming weakly rugose at extreme anterolateral angles. (9) Tegula slightly more than 1.5 times as long as wide. (10) Scutellum shiny and punctate; punctures distinct, closer posteriorly than elsewhere. (11) Pleuron rugosely punctate, areolate anteriorly. (12) Propodeum with disc slightly longer than metanotum; outline of disc obtusely V- or U-shaped to semicircular (semicircular in allotype), posterior edge sharply angulate to gradually rounded (abruptly rounded in allotype); striae fine to coarse, regular to irregular (fine and irregular in allotype), reaching edge medially, crossing edge laterally; marginal surface narrowly shiny and slightly roughened posteriorly, shiny posterolaterally; posterior vertical surface either with widely separated shallow punctures and surface between punctures shiny, or weakly roughened and impunctate; posterolateral corners evenly punctate; lateral vertical surface more closely punctate with punctures usually distinct, regular, separated by about the width of a puncture; surface between punctures finely roughened or entire surface weakly rugosopunctate (punctate in type). (13) Legs light brown; fore and hind coxae, trochanters and femora with metallic reflections; tibiae light brown, yellow-brown at apices; tarsi uniformly pale yellow-brown; hind basitarsus with erect hairs of uniform length, about as long as width of basitarsus, basal tuft slightly shorter. (14) Metasomal terga dark green, usually suffused with brownish, yellowish or reddish with apical margins brownish, scarcely contrasting in color with rest of tergum; first tergum polished anteriorly with small, widely spaced punctures throughout; smooth but less shiny dorsally, with punctures variable, usually large, distinct and irregularly spaced; second tergum with punctures of same size but very closely spaced; sterna dark brown, smooth, with short inconspicuous white pubescence; first sternum with weak metallic reflections; fourth sternum broadly and shallowly emarginate. (15) Pubescence short and white over entire body. (16) Genital capsule, seventh and eighth sterna and eighth tergum of type 1 (Figs. 31, 40, 43).

Comparisons. The females of this species look most like *persimilis* or the *striata-persimilis* integrades. The size is small, at most the size of *persimilis*. The female can be distinguished from the other species found in the United States by its small size, the small but distinctly separated punctures on the

scutum, and the lack of coarse roughening or rugosity anteriorly on the scutum (Fig. 78). It is further separated from *gratiosa* and *neglectula* by the very smooth posterior surface of the propodeum. Although this is also consistently smoother than *aurata*, *persimilis* or *striata*, the differences among these species in the posterior surface of propodeum are usually too slight to be recognized without comparative material.

The male is about the size and color of the male of *persimilis* but has the characteristics of a small *striata* with an emarginate fourth sternum, short basitarsal hair, and with the last segment of the antenna dark. The male genitalia are not perceptibly different from those of other members of the eastern species group, although there is a tendency for the process of the inner lobe of the gonostylus to be shorter and blunter than in other species (Fig. 31). Like the female, the male can be distinguished from all forms of *striata* by both its small size and its smooth but distinctly punctured scutum.

Variation. The greatest variation in *bracteata* is found in the characters of the propodeum. Males are in general more variable than females, the females varying chiefly in connection with differences in size. There is little geographical variation, probably due to the limited range and to the few specimens available outside of Texas.

As with most of the eastern species of *Augochlorella*, there is considerably more size variation in females than in males. This may be due to caste differences. In females the width of the head is usually greater than the length, but sometimes the width and length are equal. No such general pattern can be established for the males since the length-width ratio is highly variable, even though the overall variation in size is not great.

Color varies from dark green to yellow-green in both males and females, with no apparent correlation between size, date or location. There seems to be an unusual amount of discoloration, fading or bleaching in many of the specimens, especially on the metasoma. Among males, many of the specimens are coppery or reddish (see section on Specific Characters). In spite of the large proportion of specimens thus discolored, freshly caught specimens are probably normally green.

The number and size of punctures on the clypeus of the female is variable. When the punctures are sparse, the clypeus looks smooth, shiny and gently rounded, with the apex also smooth. This condition is apparent especially in the smaller (worker?) individuals. There is little variation in the size and density of punctures in males.

The supraclypeal area in both males and females is usually punctate, with the surface between punctures variably roughened. A female with a sparsely punctate clypeus will usually have a sparsely punctate supraclypeal area, with the central portion smooth and shiny. In the male the supraclypeal area may

be shiny with few punctures (14% of the specimens) or with the upper half rough and lower half shiny (67%) or entirely rough (19%).

There is little variation in the punctation of the thorax except as related to the size of the individual bee. On particularly small females the punctures are exceeding small and close and may give the scutum the appearance of being granular rather than punctate.

The rugosity of the mesepisternum also becomes very fine on small females so that the surface may look similar to that of the metepisternum.

The disc is the most variable structure in this species. Although the edge is rounded in both males and females, it may be smooth and shiny, minutely or weakly roughened, or smooth with minute reticulations. In males the punctures of the posterior vertical surface of the propodeum may reach the dorsal part of the edge on some shiny specimens, and the edge may be more or less sharply defined (but never carinate) with shininess often associated with a rounded edge and dullness with a more distinct edge. A V-shaped depression is rarely apparent but may be indicated on those specimens with a relatively defined edge.

The shape of the disc shows little variation in females. In all cases it is semicircular, like that found in *persimilis* or in the *persimilis-striata* intermediates. There is somewhat more variation in males, with the outline varying from semicircular to roundly V-shaped, but not bracket-shaped as in *striata* form A. The striae may be of any thickness from very fine to coarse, especially in males, and may vary from straight to vermiform or, as in some small females, may be so irregular as to be unrecognizable as striae. Striae usually reach the edge of the disc, at least medially, where they are usually branched or irregular. In both sexes they are frequently slightly shorter on each side of the median line, where the edge then becomes thicker (see Fig. 66). The striae are straighter and more regular in the larger females than in smaller ones. There is as much variation in the characters of the disc as in *persimilis* and its intermediates, with some specimens resembling the small *striata* form C and others resembling *persimilis*.

The posterior surface of the propodeum is smoother in some females than others but never equals the smoothness of the anterior part of the first tergum. The roughening takes the form of fine granulations or irregularities on an otherwise smooth surface.

The lateral vertical surface of the propodeum ranges from rugose to finely roughened in the females and distinctly and evenly punctured to weakly roughened, largely punctorugose or finely reticulate, in the males.

The metasomal punctures are variable in both sexes, although the type series of 72 females, all collected at the same time and place, are similar in this feature. The punctures on the first tergum in females may be absent in some small specimens or small and irregularly spaced to large, distinct, and

closely spaced. There is little indication of regional variation, although most specimens with large, close punctures are from southern Texas. The four specimens from Mexico have small to minute punctures. In males the punctures of the first tergum vary from very small to large, close to widely spaced, with no regional pattern evident. The second tergum of females usually has very small punctures regardless of the size of those of the first tergum. In males both the size and the spacing of punctures on the second tergum are variable, but usually the punctures are smaller than on the first. The third tergum in males sometimes has small but distinct punctures.

There are a few females with all white pubescence over the body. These are usually discolored individuals with brown metasoma (Victoria, Kingsville, etc.).

Distribution. From northeastern to southern Texas, southward through eastern Mexico to Hidalgo (Map: Fig. 85).

In addition to the type series, 14 males and 137 females were seen: TEXAS: *Bexar Co.*, 5 ♀ (March, July-August); *Blanco Co.*, 2 ♀; *Cameron Co.*, 6 ♂, 33 ♀ (January-August, September); *Comal Co.*, 1 ♀ (May); *Dallas Co.*, 8 ♀ (March-May); *Hidalgo Co.*, 1 ♂, 4 ♀ (April-June); *Jackson Co.*, 2 ♀ (March); *Karnes Co.*, 6 ♀ (March, September); *Kleberg Co.*, 1 ♀ (June); *Lee Co.*, 2 ♂, 20 ♀ (February-June, September); *Mavarick Co.*, 3 ♀ (April); *Nacogdoches Co.*, 1 ♀ (June); *?Nueces Co.*, 1 ♀ (April); *Refugio Co.*, 1 ♀ (April); *Robertson Co.*, 15 ♀ (April); *San Patricio Co.*, 3 ♀ (June-July); *Travis Co.*, 1 ♀; *Val Verde Co.*, 1 ♂, 1 ♀ (May-June); *Victoria Co.*, 1 ♂, 20 ♀ (March-April, September, November); *Webb Co.*, 6 ♀ (December); *Wilson Co.*, 1 ♀ (October).

HIDALGO: 1 ♂, 3 ♀ (18 mi. NE. Jacala 4750 ft.) (June). NUEVO LEÓN: 1 ♀ (General Terán) (July).

Seasonal Activity. The females are apparently active throughout the year, and the males are present at least from March through November. None of the 30 females taken between October and February was collecting pollen, and most of these specimens were clean and unworn, although both larger and smaller individuals were represented. Of the 90 specimens taken in March, the only 5 collecting pollen were captured on or after the 24th of the month. From April through September many specimens have pollen in the scopa; one was taken with a pollen load as late at September 29.

From these data it would seem that although the bees are active throughout the year, nesting takes place only from early spring into September. From variations in size of females it also seems that this species probably does have a worker caste, as do *striata* and *persimilis* (see Ordway, 1965a).

Flower Records. Agastache, Callirhoe, Chamaesaracha, Coreopsis, Dalea, Englemannia, Haplopappus, Helenium, Helianthus, Monarda, Oenothera, Opuntia, Phacelia, Prosopis, Pyrrhopappus, Ratibida, Rubus.

Augochlorella gratiosa (Smith)

Augochlora gratiosa Smith, 1853, Catalogue of the Hymenoptera in the British Museum 1:80 (descr.); Dalla Torre, 1896, Catalogus Hymenoptorum 10:95 (list); Bingham, 1897, Trans. Amer. Ent. Soc. 24:162 (list); Cockerell, 1905, Trans. Amer. Ent. Soc. 31:363 (list).

Augochlora (Augochlorella) gratiosa: Michener, 1951, *in* Muesebeck *et al.* U.S. Dept. Agr., Agr. Monogr. 2:1125 (list); Montgomery, 1957, Proc. Indiana Acad. Sci. 66:132 (list, fl.).

Augochlora festiva: Graenicher (not Smith, 1853), 1930, Ann. Ent. Soc. Amer. 32:157 (list, fl.).

Augochlorella gratiosa: Sandhouse, 1937, Jour. Washington Acad. Sci. 27:69 (tax.); Lovell, 1942, Kentucky Acad. Sci. Trans. 10:20, 21, 23 (key, descr.), Michener, 1954, Amer. Mus. Nat. Hist. Bull. 104:55 (descr.); Mitchell, 1960, Bees of the Eastern United States 1:460 (tax.).

Types. Augochlora gratiosa, holotype female, from Georgia, is in the British Museum (Natural History). Although labels on the holotype agree with those indicated by Smith's published description of *gratiosa*, the description agrees better with the holotype of *aurata*. Conversely, his description of *aurata* fits best the type of *gratiosa*. All recent descriptions and most determinations of *gratiosa* agree with the *gratiosa* type and not with Smith's description. Since Smith himself probably mixed labels and descriptions, since his descriptions are scarcely decisive, and since utmost confusion would result from reversing the application of the names in a group already so difficult taxonomically, it seems best to follow usage and the labeled types, which bear the proper locality data, and ignore the inconsistencies in the descriptions. I have not seen the types, but Dr. C. D. Michener took detailed notes on them and compared them with submitted specimens.

Description. Female: (1) Length 6 to 7 mm; head width 1.68 to 2.13 mm, averaging 1.92 mm; head length to width ratio variable. (2) Color yellowish green to blue; frons often with slight bluish reflections; metasoma usually more yellow or brownish than head and thorax. (3) Mandible without metallic coloration basally. (4) Clypeal width about equal to length, basal two-thirds shiny green with punctures irregular in size and shape, smaller and closer at margins of clypeus than centrally; apical third brown and slightly beveled with punctures large, elongate; surface between punctures smooth and shiny. (5) Supraclypeal area usually impunctate medially, lateral punctures variable in size, surface between punctures minutely roughened laterally. (6) Paraocular area punctorugose below level of antennae, coarsely rugose above. (7) Antenna dark brown; flagellum slightly lighter below than above; first segment of flagellum less than 1.5 times as wide as long, pedicel slightly longer and narrower than first flagellar segment with ratio of length to width variable. (8) Scutum roughly punctate to rugoso-

punctate; punctures small and contiguous; anterior margin rugose, becoming areolate at anterolateral corners. (9) Tegula almost 1.5 times as long as wide. (10) Scutellum coarsely roughened and granular, punctures indistinct or absent. (11) Pleuron coarsely rugose, areolate anteriorly. (12) Propodeum with disc equal to or shorter than metanotum; outline of disc bracket-shaped, profile type 1; posterior edge of disc sharply angulate posteriorly, rounded laterally; striae fine, straight, close together, extending full length of disc; posterior vertical surface finely, unevenly roughened or granular, usually dull, occasionally with very fine, indistinct, irregular, subhorizontal rugae; posterolateral corners coarsely and often linearly roughened; lateral vertical surface weakly rugose, rugae usually lineate along anterior and ventral edge, reticulate centrally. (13) Legs brown; fore and hind coxae and outer surface of fore femur with metallic reflections. (14) First metasomal tergum with anterior surface minutely and sparsely punctured, polished and finely pubescent; surface less shiny dorsally with close, minute punctures; second tergum with surface minutely reticulated, similar to following terga; sternum without metallic reflections. (15) Pubescence white ventrally on head and thorax, golden elsewhere; short and dense on genal area.

Male: (1) Length 6 to 8 mm; head with 1.72 to 2.00 mm, averaging 1.86 mm, greater than, equal to or less than length. (2) Color yellow-green to royal blue, usually bright, shiny green; frons without blue reflections on green specimens; metasoma usually slightly redder than rest of body or color uniform over entire body. (3) Mandible usually with metallic reflections basally. (4) Clypeus with large, irregularly shaped punctures separated by less than their diameters; surface between punctures smooth and shiny. (5) Supraclypeal area with punctures large, shallow and close; surface between punctures minutely roughened. (6) Paraocular area with punctures small, deep and crowded. (7) Flagellum brown above, yellow-brown below; scape dark brown except for narrow light area below; pedicel usually all yellow; last flagellar segment entirely dark; pedicel and first flagellar segment each less than 1.5 times as wide as long. (8) Scutum rough, with punctures deep and distinct medially, deep and contiguous at parapsidal lines, becoming rugose anteriorly; anterior margin variably roughened medially, rugose to areolate laterally. (9) Tegula 1.5 times as long as wide. (10) Scutellum shiny, coarsely punctate, punctures irregular in size and spacing. (11) Pleuron rugose, more coarsely so anteriorly. (12) Propodeum with disc equal or subequal in length to metanotum; outline of disc weakly bracket-shaped, dorsal surface slightly concave, posterior edge sharply to weakly angulate, well defined, rounded laterally; striae usually straight, regular, fine, widely to narrowly spaced, reaching edge posteriorly and laterally; posterior vertical surface coarsely rugose, usually without punctures; posterolateral corners rounded with posterior rugosity extending onto lateral sur-

face; lateral vertical surface less coarsely rugose than posterior surface, rugae lineate, perpendicular to anterior and ventral edges. (13) Legs brown, fore and hind coxae brightly metallic anteriorly; trochanters and femora with at least slight metallic reflections; tibiae dark yellow, usually brownish centrally; basitarsi pale yellow with following segments slightly darker; posterior basitarsus with erect hairs very long on basal third of segment, four times as long as width of basitarsus, curved at tips, becoming shorter on apical two-thirds of segment; basal tuft reduced, often inconspicuous. (14) Metasomal terga green, sometimes lighter or browner than thorax; first tergum polished anteriorly with punctures separated by slightly more than their diameters medially, closer laterally, surface smooth but less shiny dorsally, with punctures slightly larger, more distinct and denser; second tergum with punctures similar to first; first sternum strongly metallic, fifth and sometimes fourth sterna with feeble metallic reflections; fourth sternum deeply and broadly emarginate apically. (15) Pubescence white to golden-white over entire body, yellowish on tarsi. (16) Genital capsule, seventh and eighth sterna and eighth tergum of type 1 (Figs. 34, 40, 44).

Comparisons. A. gratiosa is not a very common species. It has been collected during all months of the year and most frequently from Georgia and Florida. It comes in contact with *persimilis*, *aurata*, *striata* and *bracteata*, the females intergrading morphologically with both *aurata* and *striata*. Although the males of *gratiosa* are distinct and can usually be identified by the key characters (see exception below), females are more difficult to distinguish and the subtle differences can be difficult to recognize unless samples of each are available.

A. gratiosa is characterized chiefly by the propodeal characters in the females. The disc is as short as or shorter than the metanotum (Fig. 58). Its posterior border is usually well delineated, sometimes by a weak carina but more usually by its abruptly declivitous edge which has a weak, medial, V-shaped depression (Figs. 12, 20). The striae are fine, straight, and distinct, extending the full length of the disc; the posterior vertical surface is dull and granular, usually with short subhorizontal lineate irregularities (Fig. 76). The second metasomal tergum is granulose and similar to the following terga rather than minutely punctulate as is the first tergum.

Females of *gratiosa* differ from *aurata* by the distinct, clear-cut features of the propodeal disc, by the complete, straight striae and the nature of the posterior face and second metasomal tergum. Although *aurata* may also have striae as fine and close together as those of *gratiosa*, they are rarely as straight or regular, nor do they extend onto the posterior margin of the disc (Fig. 57). Also, in *aurata*, the edge of the disc is less sharply posteriorly, usually without the medial V-shaped depression, and the posterior surface is smoother, shinier and lacks the lineate irregularities. In Texas, the two

species are easily distinguished by the above characters and in addition, the first metasomal tergum is strongly punctate in *aurata* (Fig. 82) but finely punctate as usual in *gratiosa* (Fig. 83). In *striata* the striae usually extend the full length of the disc, the disc in form A is frequently as well delineated posteriorly as in *gratiosa*, possesses the V-shaped depression and may approximate the bracket-shaped outline of *gratiosa*. However, if the striae are as straight and regular as those of *gratiosa* they usually are considerably coarser (fewer in number with greater space between them). If they are as fine as those of *gratiosa* they rarely are as straight, regular or well defined. In addition, the posterior vertical surface of the propodeum in *striata* is smoother, shinier, with minute punctures and without the lineate granular irregularities found in *gratiosa*, and the second tergum is similar to the first rather than the third or fourth terga.

A. gratiosa is apparenly more closely related to *striata* A or *aurata* than to any other group. There is comparatively little variation and variation attributed to it in the past is seemingly partly due to misidentification based chiefly, if not exclusively, on the nature of the propodeal disc. When other characters are also used, identification becomes easier. The strict definition of *gratiosa* is based chiefly on the distinct and unvarying characters in the male, as opposed to the high degree of variability found in males as well as females of *striata*.

Variation. The few variations that exist are associated chiefly with size and color. There is a wide variation in head size (Fig. 86) with the largest individuals being found in Louisiana and Alabama. A sample of 22 female specimens was measured from Florida, and all females from other states were measured. There is some indication that there may be caste differences in size although there is no correlation between width of head and season (i.e., large, small or average individuals may be found at any time of the year). Males show similar variations in size. The width of the head, with only a few exceptions is regularly greater than the length.

Body color is rather uniformly yellowish green except in Florida where it varies from dark green to deep violet-blue. Most males (14 out of 18) and about 40% of the females are blue in Florida. In these specimens there are weak metallic reflections at the bases of the mandibles in females and on the hind tibiae of males, variations rarely found in green specimens. Only 1 out of 20 females from Georgia [Tifton, Ga., 6-13-96, Lot 209 (38*)] showed such reflections on the mandibles and two green Floridian males had slight reflections on the hind tibiae [Jacksonville 9-3-11 (9); Levy Co., Fla., 9-10-55 (10)].

The extent of brown on the clypeus of females is variable from specimen to specimen with no apparent regional trend, but it does not exceed one-third of the total length.

The degree of roughness and amount of punctation on the supraclypeal area is also variable throughout the range. The frons shows very weak bluish reflections in most green specimens when the light is properly reflected from the surface but usually there are no readily visible spots of blue such as are found in *neglectula*. All blue-green specimens from Florida showed differential coloring on the various parts of the body with the head usually darker (bluer) than the thorax, and the metasoma lightest (greenest) in color.

In females from Louisiana the antennae are lighter below than above as usual, but the apical third of the flagellum is lighter above than the preceding segments.

The scutum in females is roughly and closely punctured throughout the range but is less so than that of *striata*. Punctures are usually distinct but are very close or become indeterminate or rugose anteriorly and laterally. This rugosity is not correlated with size, color or distribution, although in Florida rugosity occurs with higher frequency in blue specimens than in green ones (in 45% of the blue and 9% of the green).

The characters of the propodeum are remarkably stable in *gratiosa*, compared with the variability in the other eastern species. The sharply delineated disc is usually bracket-shaped and narrow in females, somewhat less distinctly so in males. Three of the seven females from Louisiana [2 from 8.5 a-l.ms. New Roads, 6-22-60 (20); Olivier, 5-04 (9)]; 2 of the 146 from Florida [Homestead 4-18-23 (32); Homestead 8-31-27 (9)] and one from Summerville, S.C. [5-10- (20)] out of seven seen, were found with a more rounded outline although it is difficult to draw the line between one type and the other. When the posterior margin is subbracket-shaped, the medial V-shaped depression is not evident and the sharply angulate edge becomes abruptly rounded. The size of the striae varies little and only in the males do the spaces between striae vary. On the lateral sides of the propodeum of females there may or may not be very fine lineate rugae perpendicular to the anterior and ventral margins. They are present in all males seen with the exceptions noted below in Texas. Again, this seems to be a variation within populations and not correlated with season or distribution.

The first sternum of the metasoma is variously metallic in females, strongly blue or blue-green in many darker specimens to brown with faint metallic reflections in others, especially the paler specimens.

The amount of metallic coloration on the legs of females is relatively constant although any or all trochanters and femora may be slightly colored in addition to the always colored fore and hind coxae.

All Floridian females have deep golden pubescence over all the body including the ventral parts of head and thorax, whereas in Texas, pubescence

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* See Table 1.

is paler with hairs whitish on the upper parts of the head and basal parts of the legs, in addition to the venter. The males do not vary in this character.

Male genitalia have the inner lobe of the gonostylus as shown in Figure 34. The fingerlike projection averages slightly longer than in the other eastern species but enough variation occurs in each of the eastern species that distinctions cannot usually be made. The outer lobe has long, unbranched hair as in other eastern species.

The two males from Texas [Nacogdoches, X-3-60 (42) and Victoria, VI-10-07 (9)] are divergent individuals falling between *gratiosa* and *persimilis*, not fitting either group well but appearing to be most like *gratiosa*. On the basis of characters 1, 3 and 7, the specimen from Nacogdoches is most like *gratiosa* (the specimen from Victoria is without a head). The thoracic and metasomal characters of both specimens resemble those of either *persimilis* or *gratiosa*, and the hind basitarsus of each specimen is intermediate between the two species although more similar to *gratiosa* than to *persimilis*.

Distribution. From New Jersey and Washington, D.C., southward to the keys of Florida, along the Gulf Coast states into southeastern Texas, extending inland as far as northern Georgia and eastern Tennessee (Map: Fig. 87).

A total of 29 males and 199 females have been seen: ALABAMA: *Mobile Co.*, 1 ♀; *Washington Co.*, 1 ♀ (June). FLORIDA: *Alachua Co.*, 1 ♂, 8 ♀ (February-May, August, October, December); *Bradford Co.*, 1 ♂, 1 ♀ (April); *Brevard Co.*, 1 ♂, 1 ♀ (April, November); *Broward Co.*, 2 ♀ (February, October); *Collier Co.*, 1 ♂, 5 ♀ (April); *Dade Co.*, 13 ♂, 49 ♀ (January-April, June-December); *Duval Co.*, 1 ♂, 2 ♀ (April, August, November); *Gadsden Co.*, 1 ♀ (April); *Hendry Co.*, 2 ♀ (July, October); *Hernando Co.*, 1 ♀ (December); *Highlands Co.*, 6 ♀ (April-June, August); *Hillsborough Co.*, 3 ♀ (April, August); *Lake Co.*, 8 ♀ (January-February, April); *Lee Co.*, 1 ♀ (March); *Levy Co.*, 1 ♂, 19 ♀ (February, April, June, September); *Manatee Co.*, 2 ♀ (February, April); *Marion Co.*, 4 ♀ (February, April); *Martin Co.*, 1 ♀ (March); *Monroe Co.*, 4 ♀ (January, May); *Nassau Co.*, 4 ♀ (July-August); *Orange Co.*, 4 ♀ (February-April, December); *Palm Beach Co.*, 2 ♀ (March, September); *Pasco Co.*, 3 ♀ (January, August); *Polk Co.*, 2 ♀ (May, September); *Putnam Co.*, 6 ♀ (May); *Seminole Co.*, 1 ♀; *St. Lucie Co.*, 1 ♀ (April); *Volusia Co.*, 1 ♀. DISTRICT OF COLUMBIA: 1 ♂ (May). GEORGIA: *Haralson Co.*, 1 ♀ (June); *Lowndes Co.*, 2 ♀ (July); *Thomas Co.*, 2 ♀ (April); *Tift Co.*, 5 ♂, 14 ♀ (June); *Townes Co.*, 1 ♂ (August); *Walker Co.*, 1 ♀ (June); *Ware Co.*, 1 ♂, 2 ♀ (July). LOUISIANA: *East Baton Rouge Parish*, 2 ♀ (July); *Iberia Parish*, 1 ♀ (May); *Pointe Coupée Parish*, 3 ♀ (June); *Tangipahoa Parish*, 1 ♀ (June). MISSISSIPPI: *Forrest Co.*, 3 ♀ (August-September). NEW JERSEY: 1 ♀. NORTH CAROLINA: *Columbus Co.*, 1 ♀ (August); *Moore Co.*, 1 ♀ (Novem-

ber); *Tyrrell Co.*, 1 ♀ (July); *Wake Co.*, 3 ♀ (April-May). SOUTH CAROLINA: *Dillon Co.*, 3 ♀ (April); *Dorchester Co.*, 1 ♀ (May). TENNESSEE: 1 ♀. TEXAS: *Colorado Co.*, 1 ♀ (March); *Jackson Co.*, 3 ♀ (March); *Nacogdoches Co.*, 1 ♂ (October); *Victoria Co.*, 1 ♂ (June).

A single male (9) from Washington, D.C., and one female labeled "N. J. 1786" (9) were examined, although no specimens of this species have otherwise been taken north of North Carolina. One female [Chickamauga, Ga. VI-24-98 (38)] taken in the northwest corner of Georgia in Walker County and one female labeled "E. Tenn." (38) represent the most inland records. Although specimens are scarce and widely scattered in this region, they do not differ from others except that the individual from Walker County is somewhat paler with more brown on the metasoma than usual.

Lovell (1942) records this species from Jefferson County, Kentucky, in the north central part of the state. I have not seen any of his specimens but it seems unlikely that *gratiosa* ranges that far inland.

Seasonal Activity. Females of *gratiosa* are active throughout the year in Florida and have been taken from April through September in other states.

FIG. 89. Distribution of *A. gratiosa*.

Males have been collected from March through December in Florida and June through October elsewhere. Pollen collectors are found from mid-April at least through July and probably well into the fall throughout the range and from the end of February to September in Florida.

Flower Records. Aster, Ampelopsis, Asclepias, Berteroa, Bidens, Callicarpa, Cassia, Chrysobalanus, Chrysopsis, Cirsium, Citrus, Clethra, Crataegus, Crotonopsis, Cunila, Erigeron, Eryngium, Galactia, Gerardia, Gossypium, Helianthus, Hypericum, Ilex, Ixora, Jacquemontia, Lepidium, Malva, Melilotus, Aenothera, Opuntia, Piriqueta, Polygala, Polygonum, Pterocaulon, Pycnothymus, Rhus, Rubus, Sabal, Senecio, Solidago, Taraxacum, Teucrium, Vaccinium, Verbena, Warea.

Augochlorella aurata (Smith)

Augochlora aurata Smith, 1853, Catalogue of the Hymenoptera in the British Museum 1:82 (descr.); Cresson, 1887, Trans. Amer. Ent. Soc., Suppl. 14s:293 (list); Dalla Torre, 1896, Catalogus Hymenoptorum 10:94 (list); Bingham, 1897, Trans. Amer. Ent. Soc. 24:162 (list); Brimley, 1938, Insects of North Carolina p. 454 (list, fl.).

Augochlora austrina Robertson, 1893, Trans. Amer. Ent. Soc. 20:147 (descr.); Dalla Torre, 1896, Catalogus Hymenoptorum 10:94 (list); Cockerell, 1922, Proc. U.S. Nat. Mus. 60:16 (descr.).

Augochlora (Augochlorella) aurata: Michener, 1951, *in* Muesebeck *et al.*, U.S. Dept. Agr., Agr. Monogr. 2:1125 (in part) (list).

Augochlorella aurata: Sandhouse, 1937, Jour. Washington Acad. Sci. 27:71 (in part) (tax.); Mitchell, 1960, Bees of the Eastern United States 1:459 (in part).

Types. Augochlora aurata, holotype female, from St. John's Bluff [? St. Johns Co.], Eastern Florida, is in the British Museum (Natural History). Although labels on the holotype agree with those in Smith's published description of *aurata*, the description agrees best with the holotype of *gratiosa*. Conversely, his description of *gratiosa* better fits the type of *aurata*. For further discussion of this problem, see *Augochlorella gratiosa*. I have not seen the type but Dr. C. D. Michener took detailed notes on it and compared it with submitted specimens. *Augochlora austrina*, holotype female, No. 12859 [Robertson's number], from Inverness [Citrus Co.], Florida, 1892, is in the Robertson Collection at the Illinois Natural History Survey. For the most part, the *aurata* of Sandhouse (1937) and Mitchell (1960) is *persimilis*.

Description. Female: (1) Body length 7 mm; head width 1.58 to 1.98 mm, averaging 1.84 mm, width to length ratio variable. (2) Color yellow-green to blue-green; frons without bluish reflections on green specimens, metasoma similar in color to other body regions. (3) Mandible with basal third dark brown, yellow-brown centrally, rufous at tip, rarely with metallic

reflection at base. (4) Clypeal width subequal to length; basal part green with large, irregularly spaced punctures; apical fifth or less, brown, brown area not exceeding one-third, slightly beveled; punctures in brown area round, or slightly elongate when brown area exceeds diameter of puncture; surface between punctures usually shiny and smooth. (5) Supraclypeal area variably punctate, surface between punctures shiny and smooth or finely roughened. (6) Paraocular area punctorugose to rugose below antenna, more coarsely rugose above. (7) Antenna dark brown, often slightly lighter below than above; pedicel with length subequal to width, first flagellar segment wider than long. (8) Scutum coarsely punctate; punctures close to contiguous over entire dorsum, similar to frons; anterior margin and anterolateral corners finely rugose to finely areolate. (9) Tegula almost twice as long as wide. (10) Scutellum roughened or shallowly and irregularly punctate. (11) Pleuron finely rugose, becoming areolate anteriorly. (12) Propodeum with disc equal to or slightly longer than metanotum; outline of disc bracket-shaped to semicircular, usually weakly bracket-shaped, forming blunt point medially, profile type 2; posterior edge of disc distinct, abruptly rounded to sharp, gradually rounded laterally; striae fine, close, wavy, usually irregular, ending just before edge or at edge medially, often leaving edge slightly raised, roughened and dull, reaching or crossing edge laterally; posterior vertical surface evenly and finely granular, not rough; posterolateral corners not prominent, usually slightly more roughened than posterior surface; lateral vertical surface weakly rugose. (13) Legs brown, fore and hind coxae, mid and hind trochanters and femora with metallic reflections. (14) First metasomal tergum with anterior surface shiny but not polished, with numerous widely spaced punctures; dorsal punctures minute and close, or large, close and distinct (Texas); first sternum without metallic reflections. (15) Pubescence golden-white on dorsum and legs and ventrally on metasoma; white ventrally on head and thorax; pubescence short and thick but not dense on genal area.

Male: (1) Length 7 mm; head width 1.81 to 1.91 mm, averaging 1.86 mm, width to length ratio variable. (2) Color bright green; often with bluish reflections on frons; metasoma often slightly redder or browner above than on other parts of body. (3) Mandible with dark metallic reflections basally. (4) Clypeus with punctures variable in size and spacing; surface between punctures shiny and smooth. (5) Supraclypeal area variably punctured with surface smooth and shiny or irregularly roughened. (6) Paraocular area finely punctorugose. (7) Flagellum dark brown above, yellowish brown below; scape dark brown; pedicel partially light brown above, dark brown below; last flagellar segment entirely dark brown; pedicel and first flagellar segment each about 1.5 times wider than long. (8) Scutum with punctures distinct but crowded medially, separated by less than their di-

ameters, becoming contiguous at parapsidal lines; anterior margin rugose, becoming areolate laterally. (9) Tegula twice as long as wide. (10) Scutellum shiny, punctate to punctorugose. (11) Pleuron rugose, becoming areolate anteriorly. (12) Propodeum with disc equal to or slightly longer than metanotum; outline of disc weakly bracket-shaped to obtusely V-shaped, posterior edge abruptly rounded; striae fine, wavy and irregular, reaching edge posteriorly, crossing edge laterally; posterior vertical surface and posterolateral corners finely rugose or roughened; lateral vertical surface rugose. (13) Legs brown, with fore and hind coxae, trochanters and femora reflecting green; tibiae reflecting green medially, testaceous at extremities; tarsi testaceous; hind basitarsus with erect hairs uniform in length, up to 1.5 times as long as width of segment, variable among individuals, pale yellow in color; basal tuft distinct. (14) Metasomal terga green; first tergum polished, with widely scattered fine punctures anteriorly, smooth but less shiny dorsally, punctures small and close; sterna brown, pubescence short, fine over entire sterna; first sternum with weak metallic reflections, fourth sternum shallowly emarginate. (15) Pubescence white on head, white to golden dorsally on thorax, golden on metasoma and legs. (16) Genital capsule, seventh and eighth sterna and eighth tergum all of type 1 (similar to Figs. 32, 40, 43).

Comparisons. Very few specimens of *aurata* have been collected outside of Florida and Texas although nine specimens are available from Alabama, Georgia and North Carolina. The females are most similar in appearance to those of *gratiosa* and the males to those of *striata*, the range of variation in Florida overlapping those of both *striata* A and *gratiosa*.

The females can usually be distinguished from *gratiosa* by the slightly longer propodeal disc, the flatter bracket-shape (Figs. 57, 58) and less acutely angulate posterior edge of the disc and the smoother posterior vertical surface of the propodeum. In Texas they can be additionally distinguished by the deep, crowded, distinct punctures on the first and second metasomal terga (Figs. 82, 83). They can be distinguished from *striata* A in North Carolina and Georgia by the flatter bracket-shaped disc with a less acutely angulate posterior edge and the finer, more irregular striae, and in Florida usually by finer more irregular striae and the less rugose sculpturing on the thorax. There are no *striata* females in the south with which this species could be confused.

The males are similar to *striata* with short basitarsal hairs of more or less uniform length, shallowly emarginate fourth metasomal sternum and dark tipped antennal flagellum. The range of variation is not known since only five males from Georgia have been positively identified and these were similar to one another. Ten males from Florida are also tentatively included. These look very similar to variants of *striata*. The males from Georgia differ

from all *striata* males in the flatter, more finely striate, propodeal disc. The difference in scutal punctures will also separate what are believed to be Floridian *aurata* from Floridian *striata*.

I believe that *aurata* is more closely related to *striata* than to *gratiosa* although it is more difficult to distinguish the females from those of *gratiosa*. The paucity of males may reflect limited collecting at the proper time of year or their occurrence in locations other than where the females were taken or it may be that they have not been distinguished from *striata* males since the nature of the variation in *striata* has not been fully evaluated.

Variation. There is comparatively little variation in size although particularly large or small individuals may occasionally be found in Florida. The color, usually a yellow-green to bright green, is often blue-green in Floridian specimens although yellow-green individuals may also be found.

The clypeus is apically brown, usually for one-sixth to one-fourth its length in females, but is one-third brown in some specimens from Florida and one-half brown in some specimens from Georgia. The face looks long (Fig. 52) in all Texan and some Floridian specimens but round in the rest (Fig. 53).

The propodeal disc of the female is usually slightly longer than the metanotum, or it may be equal to the metanotum but is not shorter. The disc is nearly always at least weakly bracket-shaped and bluntly pointed medially (Fig. 57). The edge is usually abruptly rounded and distinct although it may be either sharply angulate or rounded and indistinct in some specimens from Texas and Florida. There is more variability among Floridian specimens in this character than elsewhere in the range; the four specimens from Georgia are all similar to Figure 57. The striae are rarely as straight and well defined as in *gratiosa* (except for a few from Florida) but are very fine, irregular or vermiform, with no definite spaces between them. The posterior edge is usually minutely roughened when rounded and the striae end gradually in this roughened area. The most striking variation occurs in the metasomal punctures of specimens from Texas. Throughout the rest of the range the punctures are small, close, shallow, and almost inconspicuous as in *gratiosa* (Fig. 83). In Texas, the punctures, although also close, are slightly larger, much deeper, and more conspicuous (Fig. 82), giving the tergum a coarse or roughened appearance.

Males have been seen only from Georgia and Florida. Those from Georgia have the disc resembling that of the females, widely bracket-shaped, with fine irregular striae ending in a minutely roughened area at the edge. None of the presumed *aurata* males from Florida have discs similar to this or to that of the females. The shape of the disc in Florida varies from weakly bracket-shaped and narrow to long and roundly V-shaped. The striae are usually rather thin and close, and the posterior edge is usually abruptly

rounded; the posterior surface may be weakly roughened as in the Georgian specimens or rugose as in many male *striata*. These specimens are all different from one another, resembling males of *striata* s but are unlike the *striata* A from Florida. There is considerable variation in the characters of the disc of females in Florida; perhaps the variability is as great in males. Due to the uncertainty in identification of the Floridian males, the above description of the male is based solely on the specimens of *aurata* from Georgia.

Throughout Florida, occasional female specimens are found that are brilliantly shiny, very finely punctured, with a body surface finely roughened or at most, weakly rugose on the thorax. These individuals are always dark blue-green in color but in all other respects are similar to other Floridian *aurata*. Eleven such specimens have been seen. They do not form an isolated population nor have corresponding males been found and therefore it seems improbable that these few specimens represent a different species. [Such specimens are from: W. Palm Beach, IX-3-27 (Graenicher) (32*); Highlands Co., VI-6-60 (Weems) (10); Pasco Co., III-2-57 (Weems) (10); Port Sewell, II-24-29-44 (Sanford) (32); Jacksonville Beach, VIII-5-36 (Mitchell) (33); Archibald Res. Sta., Lake Placid, IV-6-61 (Dietrich) (32)].

Distribution. This species is found from Florida along the Gulf coast into Texas and northward along the east coast as far as North Carolina (Map: Fig. 88).

A total of 15 males and 163 females have been seen: ALABAMA: *Houston Co.*, 1 ♀ (July). FLORIDA: *Alachua Co.*, 1 ♂, 8 ♀ (March-May, October, December); *Brevard Co.*, 1 ♂, 10 ♀ (March-April, July, November); *Broward Co.*, 2 ♀ (February); *Collier Co.*, 1 ♀ (April); *Dixie Co.*, 1 ♂ (August); *Duval Co.*, 1 ♂, 16 ♀ (May, August-September); *Flagler Co.*, 2 ♀ (February, December); *Glades Co.*, 1 ♀ (March); *Hendry Co.*, 1 ♂ (July); *Highlands Co.*, 5 ♀ (April, June); *Hillsborough Co.*, 3 ♀ (April); *Indian River Co.*, 1 ♀ (March); *Jackson Co.*, 1 ♀ (August); *Levy Co.*, 1 ♀ (September); *Marion Co.*, 1 ♀ (March); *Martin Co.*, 1 ♀ (February); *Nassau Co.*, 2 ♀ (July); *Okeechobee Co.*, 1 ♀ (April); *Orange Co.*, 1 ♂, 9 ♀ (March-June); *Palm Beach Co.*, 2 ♂, 5 ♀ (September); *Pasco Co.*, 1 ♀ (March); *Pinellas Co.*, 1 ♀ (April); *Polk Co.*, 3 ♀ (March-April); *St. Lucie Co.*, 1 ♀ (April); *St. Johns Co.*, 2 ♀ (April); *Seminole Co.*, 4 ♀ (May, July); *Volusia Co.*, 2 ♂, 6 ♀ (June-September). GEORGIA: *Brooks Co.*, 1 ♀ (March); *Dougherty Co.*, 1 ♂ (June); *Lowndes Co.*, 4 ♂ (July); *Pike Co.*, 1 ♀ (April); *Thomas Co.*, 1 ♀ (April). NORTH CAROLINA: "N.C." 1 ♀. TEXAS: *Aransas Co.*, 4 ♀ (July-August); *Bastrop Co.*, 2 ♀ (May); *Bee Co.*, 1 ♀ (May); *Cal-*

* See Table 1.

houn Co., 2 ♀ (April); *Cameron Co.*, 4 ♀ (June); *Coloradlo Co.*, 1 ♀ (April); *Fayette Co.*, 3 ♀ (March); *Goliad Co.*, 5 ♀ (May); *Jackson Co.*, 4 ♀ (March, July); *Kenedy Co.*, 2 ♀ (April); *Lee Co.*, 20 ♀ (March-June); *Nacogdoches Co.*, 3 ♀ (April, September); *Refugio Co.*, 1 ♀ (April); *Victoria Co.*, 16 ♀ (February-May, August, October); *Waller Co.*, 1 ♀ (April).

Seasonal Activity. Females of *aurata* are apparently active throughout the year and have been collected from early February through December. Males are active from early June through November. Pollen collectors have been found from early February to the beginning of September although nesting activities may continue later into the fall.

Flower Records. Aster, Cirsium, Citrus, Crataegus, Lythrum, Opuntia, Polygonum, Rubus, Viburnum.

Augochlorella persimilis (Viereck) (n. comb.)

Halictus (Oxystoglossa) persimilis Viereck, 1910, *in* Smith. Ann. Rept. New Jersey State Mus. for 1909, p. 688 (list) (new name for *Augochlora similis* Robertson, preoccupied in *Halictus;* Viereck's identification was in error but his new name stands for *similis* Robertson).

Augochlora persimilis: Rau, 1922, Trans. Acad. Sci. St. Louis 24:33 (list, fl.); Graenicher, 1935, Ann. Ent. Soc. Amer. 28:302 (list).

Augochlorella persimilis: Ordway, 1964, Jour. Kansas Ent. Soc. 37:139-152 (biol.); Ordway, 1965, Insectes Sociaux 12:291-308 (biol.); Ordway, in press, Jour. Kansas Ent. Soc. (biol.).

Augochlora similis Robertson, 1893, Trans. Amer. Ent. Soc. 20:146 (descr.); Robertson, 1894, Trans. Acad. Sci. St. Louis 7:436-472 (fl.); Robertson, 1896, Trans. Acad. Sci. St. Louis 7:175 (fl.); Dalla Torre, 1896, Catalogus Hymenoptorum 10:96 (list); Bridwell, 1899, Trans. Kansas Acad. Sci. 16:210 (list); Cockerell, 1899, Ent. News 10:3 (list); Graenicher, 1911, Bull. Pub. Mus. Milwaukee 1:234 (list); Banks, 1912, Ent. News 23:107 (fl.); Brimley, 1938, Insects of North Carolina, p. 455 (list, fl.).

Augochlora (Oxystoglossa) similis: Robertson, 1902, Canad. Ent. 34:247 (key).

Oxystoglossa similis: Robertson, 1928, Flowers and Insects, pp. 1-221 (fl.); Pearson, 1933, Ecol. Monogr. 3:386, 396 (biol.).

Halictus (Oxystoglossa) xystris Vachal, 1911, Misc. Ent. 19:50 (key, descr.); Mitchell, 1960, Bees of the Eastern United States 1:460 (tax.).

Augochlorella aurata: Sandhouse, 1937, Jour. Washington Acad. Sci. 27:71 (in part) (tax.); Lovell, 1942, Kentucky Acad. Sci. Trans. 10:20, 21, 23 (key, descr.); Mitchell, 1960, Bees of the Eastern United States 1:459 (in part) (tax.); Sakagami and Michener, 1962, Nest Architecture of Sweat Bees, pp. 1-135 (biol.); Eickwort and Fischer, 1963, Ann. Ent. Soc. Amer. 56:350 (list) (misidentifications).

Augochlora (Augochlorella) aurata: Michener, 1951, *in* Muesebeck *et al.*, U.S.

Dept. Agr., Agr. Monogr. 2:1125 (in part) (list); Montgomery, 1957, Proc. Indiana Acad. Sci. 66:132 (distr., fl.) (misidentifications).

Augochlorella neglectula: Dreisbach, 1945, Michigan Acad. Sci. Arts and Letters. Papers 30, p. 225 (misidentification).

Types. Augochlora similis, lectotype female here designated, No. 1104, from Carlinville, Macoupin Co., Illinois, 1891, is in the Robertson Collection at the Illinois Natural History Survey. This specimen has been selected from among 19 syntype females. It agrees with the original description and may be considered "typical" of the species. There are eight male syntypes in the Robertson Collection, one (No. 474, Robertson's number) being a large *striata* and 18 syntype females all from Carlinville, Macoupin Co., Illinois, with dates from 1885-1887 and 1890-1892. *Halictus xystris* Vachal, lectotype female and two syntypes each labeled "xystis [sic] ♀ Vach." are located in the Vachal collection at the Museum National d'Histoire Naturelle, Paris. I have designated as lectotype one of the three syntypes that best fits the description and the only one with a locality label. The handwritten label reads "*Augochlora pura*, from *Potentilla*, S. Ill. June. . ." The label has been cropped closely, obliterating the rest of the date. It is probable that Vachal mistook the handwritten "S. Ill." for "S.W." and published the locality as "southwestern United States". Two of the three specimens including the lectotype resemble *persimilis* from southern Illinois. The third is a *persimilis-striata* intermediate that might be a small *striata* form c. It does not agree as well with the original diagnosis as the propodeal striae are regular and almost reach the edge of the rounded disc so that there is scarcely any smooth shiny area beyond the striations. I was able to see these specimens thanks to the generosity and cooperation of Mademoiselle S. Kélner-Pillault of the Museum National d'Histoire Naturelle, who lent them to me.

Although Sandhouse (1937) synonymized this species with *aurata* Smith 1853, the type of *aurata* is different from Robertson's *similis*.

Description. Female: (1) Length 5 to 6 mm; head width 1.44 to 1.91 mm, averaging 1.69 mm; head width greater than length. (2) Color bright green to yellow- or coppery-green; frons without bluish reflections; metasoma usually more golden, coppery or brownish than head and thorax. (3) Mandible with basal third dark brown, yellow-brown centrally, rufous at tip, without green basal reflections. (4) Clypeal length equal to width or slightly longer; basal part green with punctures variable in size, smallest and closest near basal angles, becoming larger apically and separated by about twice their diameters or more; apical third to two-thirds of clypeus brown and slightly beveled, with elongate punctures becoming shallow and indistinct at apex, giving apex roughened appearance; surface between punctures smooth and shiny. (5) Supraclypeal area with surface weakly roughened,

punctures small just below antennae and along subantennal sutures, sometimes with few scattered punctures centrally. (6) Paraocular area usually closely punctate below antenna, finely rugose above antenna. (7) Antenna brown, flagellum lighter below than above; first flagellar segment wider than long; pedicel slightly longer and narrower than first flagellar segment, ratio of length to width variable. (8) Scutum coarsely and irregularly punctured, punctures close, usually with little or no space between them, rarely separated by as much as a puncture width centrally, becoming closer and coarser laterally; surface between punctures, when present, smooth and shiny centrally; anterior margin roughened with surface finely lineolate and dull medially, becoming rugose laterally and at anterolateral angles. (9) Tegula twice as long as wide. (10) Scutellum shiny and roughened, irregularly punctate or rugose. (11) Pleuron irregularly rugose, becoming coarsely areolate anteriorly. (12) Propodeum with disc slightly longer than to a little more than 1.5 times as long as metanotum; outline of disc roundly semicircular, profile type 2, posterior edge indistinct and gradually rounded; striae variable, usually irregular, branched, vermiform, occupying 60 to 80 percent the length of disc medially, reaching edge laterally; surface beyond striae smooth but minutely lineate or finely roughened; posterior vertical surface shiny and smooth with sparsely scattered minute punctures, or surface finely granular with granular texture extending across upper part of posterolateral corner to lateral surface; lateral vertical surface weakly rugose or coarsely roughened with widely separated or reticulated rugae. (13) Legs brown; fore and hind coxae strongly metallic; trochanters and femora with feeble metallic reflections. (14) First metasomal tergum with anterior surface brilliantly polished with a few widely spaced fine punctures; punctures more numerous and surface less brilliant dorsally; second tergum with numerous fine punctures separated by about twice their diameters; surface usually dull; first sternum sometimes darker than others, often greenish but not metallic. (15) Pubescence golden-white dorsally on head, thorax, apical segments of legs, and on dorsal and last two ventral metasomal segments; white ventrally on head and thorax; white or golden on basal segments of legs and ventral part of metasoma.

Male: (1) Length 7 mm; head width 1.45 to 1.80 mm, averaging 1.66 mm; head width equal to, greater than or less than length with no regional or seasonal pattern. (2) Color yellow-green to coppery-green; frons without blue reflections; metasoma usually more golden or reddish than rest of body. (3) Mandible with or without metallic reflections basally. (4) Clypeal surface shiny between rather large punctures; punctures irregular in size, shape and spacing, smallest along basal edge. (5) Supraclypeal area with small scattered punctures; surface between punctures minutely roughened, dull; rougher immediately below antennae than just above clypeus, or shiny and

smooth. (6) Paraocular area finely and closely punctate to rugosopunctate. (7) Flagellum dark brown above, yellow below; scape entirely dark brown except for small apical yellow area on underside; pedicel dark brown and yellow; last flagellar segment rarely darker below than preceding segments, but if so, then only partially dark apically; pedicel and first flagellar segment about 1.5 times as wide as long. (8) Scutum shiny with punctures distinct, separated by less than their own diameters medially, slightly closer laterally, smaller and closer posteriorly; anterior margin roughened to finely rugose medially to rugose laterally. (9) Tegula more than 1.5 times as long as wide. (10) Scutellum shiny, coarsely punctate, punctures distinct but irregular in size and spacing. (11) Pleuron rugose to rugosopunctate, coarsely areolate anteriorly. (12) Disc of propodeum longer than metanotum; outline of disc semicircular, posterior edge prominent, abruptly rounded medially, gradually rounded laterally; striae variable, usually moderately coarse, irregular or wavy, not quite reaching edge medially, attaining edge laterally; surface of disc beyond median striae coarsely roughened to smooth and shiny with minute reticulations; posterior vertical surface usually smooth and brilliant, or only weakly and irregularly roughened, upper part of posterolateral corners minutely punctate to weakly roughened; lateral vertical surfaces roughened to rugose or finely areolate with weak horizontal rugae along anterior and ventral margins. (13) Legs with fore and hind coxae, trochanters and femora bright green, tibiae yellow-brown, usually darker centrally, hind tibia sometimes weakly reflecting green on inner surface; tarsi pale yellow; hind basitarsus with erect hairs along apical two-thirds of segment only, longer basally than apically; longest hairs about twice as long as width of segment, usually slightly curved at tips; basal third of segment without erect hairs; basal tuft short and sparse. (14) Metasomal terga green with apical margins usually narrowly brown; first tergum polished anteriorly with few, widely scattered fine punctures, smooth but less shiny dorsally, punctures denser, minute, separated by 1.5 times their diameters or less; sterna brown, first sternum with green reflections; fourth sternum emarginate apically. (15) Pubescence short, thick and white between antennae and on paraocular areas, white on cheeks, venter of thorax and basal segments of legs; white to golden-white on clypeus, frons and vertex, dorsum of thorax, on tibiae and tarsi and metasoma. (16) Genital capsule, seventh and eighth sterna and eighth tergum of type 1 (Figs. 33, 40, 43).

Comparisons. Although the range of *persimilis* overlaps that of four other species of *Augochlorella*, females intergrade only with form c of *striata*. There is no sure way of separating females of the two species where intermediates occur although the key will distinguish a majority. Males of the two species remain distinct and are readily distinguishable by the key characters.

Both males and females of *persimilis* may superficially resemble *bracteata* in size, coloration and often in characters of the propodeal disc. There is however, only slight overlap in ranges and the consistantly rougher thorax of *persimilis* effectively serves to distinguish the two species.

Apart from *bracteata* and *striata* c, *persimilis* can be distinguished from the eastern species by its generally smaller size, smoother body and propodeal disc with rounded posterior edge and short medial striae. The males are distinguishable by the long hind basitarsal hairs (Fig. 50) although in Texas two male specimens of *gratiosa* were found that looked very similar to those of *persimilis* (see variation under *gratiosa*). The fourth metasomal sternum of the males is about as emarginate as that of *gratiosa*, so that any distinction is difficult to make, especially when the segments are telescoped.

Variation. Body color varies in *persimilis* from blue-green to golden or coppery-yellow. The metasoma is usually lighter in color than the head and thorax (it may be browner or yellower). The males are predominantly yellowish green throughout the range except in Arkansas, Virginia and Georgia where all individuals seen are coppery in color. In Kansas, where a large sample was available, 85% of the females are bright green, 14% yellow-green or coppery and 1% blue-green. More than half the specimens are yellow-green or coppery-green in Tennessee, North Carolina, Maryland, Texas, Arkansas, Indiana, Missouri, Minnesota and Virginia, but populations are predominantly bright green in Illinois, Kansas, Nebraska and Wisconsin. About half the specimens are bright green in Louisiana and Oklahoma.

In both males and females, the width of the head varies widely within any one area. When measurements were pooled for each sex, however, normal distributions were obtained with only a slightly skewed distribution in the case of males. The head width may be greater than, equal to or less than the length in the case of the males with only slight differences between width and length. In females the width is consistently greater than the length. Little difference in size was found between populations from different areas. In females, the average head width of field caught bees is greater during the spring (March, April, May) (Fig. 89) than during other months; at least throughout much of the range only queens are present in spring. During the rest of the season, both queens and workers are present. (See Ordway, 1965a, for discussion of size and caste data.)

The length of the clypeus in females is about equal to the width giving the face a round appearance, especially in smaller individuals. The spacing and number of punctures on the clypeus are variable among individuals. Also, the extent of the brown color on the apical portion varies from about one-third to one-half the length. No regional trends were observed for either character.

The supraclypeal area is always roughened in females and at least partially so in males. The amount of punctation in this area is variable as is the degree of roughness. The paraocular areas are usually punctate near the lower ends of the eyes and finely rugose elsewhere. However, in about one percent of the females from throughout the range the roughness extends to the bases of the mandibles.

The antennae of some males have the last flagellar segment slightly darker below than the preceding segments but the segment is only partially dark and the darkening is slight.

The punctures of the scutum in females are rather constant in size but vary in respect to their spacing. The punctures are always distinct centrally but are closer toward the edges and the scutum may become rugose laterally and anteriorly. The amount of space between the central punctures varies; usually the punctures are close together with little space between, giving the surface a rather rough appearance. The surface looks smoother when the punctures are more widely spaced as in many of the specimens from Arkansas and a few from Virginia. The anteromedial surface is finely lineolate or roughened. This roughening extends for varying distances along the median suture but is always evident at least at the anterior end of the suture. There is little variability in scuta of males.

The scutellum in males and many females has punctures of various sizes and unequal spacing. In the females the scutellum may have distinct punctures or the punctures may run together or the surface may be entirely rugose, with all conditions occurring in populations throughout the range. When the punctures are distinct in females, they are closer and smaller at the edges, becoming rugose along the posterior margin and along the medial line, usually being shallower and smaller than those on the scutum. In males the punctures may vary from widely spaced to crowded.

There is little variation in the pleural region. Although the sculpturing of the mesepisternum and metepisternum is about equally coarse, the rugose patterns of the two areas are different.

As in other eastern species the propodeal area is highly variable, yet in females, it remains the most diagnostic character available. The disc is longer than the metanotum in both sexes. Only 1 male out of about 50 measured was found with disc and metanotum equal in length [Illinois, 566, Hart Coll. (14*)]. In males the metanotum showed greater variation in length than the propodeum; in females, both structures varied in length.

The shape of the margin of the disc and the lack of a V-shaped midapical depression is unvarying in all males. In 2 males out of about 300 examined, the usually thick posterior margin was thin, abruptly angulate and almost

* See Table 1.

carinate [Indiana, Warren Co., VII-25-50 (16); Missouri, Tecumseh, VI-9-60 (25)]. In females the shape of the margin varies little and there is no V-shaped depression. Although the smooth, lineate, posterior part of the disc does extend onto the posterior surface in the shape of a V, there is no median depression as is found in *gratiosa* or some *striata*. The posterior edge in females usually is thickened as in males, but may be very narrow, flat or in certain cases completely rounded so that there is no clear demarkation of the margin [Illinois, 16966 (14); Nebraska, Nebraska City, VIII-23-01 (28)]. The striae are extremely variable in both sexes although more so in females. Variation in males is limited chiefly to the thickness of the striae and to the amount of their separation. The striae in both males and females may be regular and straight or, more usually, at least partially wavy, branched or irregular. All grades of irregularity occur in the striae of females, but rarely are the striae straight and distinct in the central area, and in no case was a specimen found in which the striae were both thick and straight, *and* widely spaced as in the large *striata* c or Floridian *striata* A. Although the striae rarely exceed 80% of the length of the disc centrally, specimens may be found where they reach into the lineate region medially [Texas (38); Kansas, Douglas Co. (20) etc.]. The lateral striae are nearly always rather straight and distinct in both males and females. Various types of "extreme" conditions appear periodically in females of various populations. It is not feasible to cite them all, but they include forms without striae and with only fine roughening along the basal half of the disc [Kansas, Lawrence, VIII-3-58 (20); Wisconsin, Oshkosh, VIII-7-16 (47)], or with fine rugae running transversely and joining with lateral striae [Kansas, Douglas Co., IX-5-53 (28); Missouri, Buffalo, VI-8-52 (20)] or with striae so irregular that there is no linear quality at all [Illinois, Algonquin, VI-4-09 (14); Missouri, Big Spring St. Pk. (20) etc.]. The posterior surface of the propodeum of females may be shiny and smooth or slightly less brilliant and granular in nature. No specimen was seen with rugae on this area. Specimens from the east (Maryland, Georgia, North Carolina, Virginia) are predominantly shiny and smooth; in other areas both conditions occur in about equal proportions. Three specimens were found in which the propodeal area was somewhat misshapen with the result that the posterior surface was "wrinkled looking," shiny and without the usual minute punctures [Arkansas, Jonesboro, VI-29-52 (20); Wisconsin, Oshkosh, VIII-7-16 (47); Nebraska, Nebraska City, VIII-23-01 (28)]. In males the posterior surface is usually very shiny and only slightly but variously roughened. This roughening may be in the form of shallow punctures which may or may not be distinct or may be merely unevenness of the surface. Two specimens, however, were found with very rough and somewhat duller posterior surfaces [Illinois, 32408 (14); Illinois, Willow Spr., VIII-12-05 (14)].

There is little variation in coloration of the legs in either males or females except for the intensity of green. This coloration seems to be correlated with the darkness of body coloration, the paler (yellower) individuals having less strongly green legs. Such variation occurs throughout the range. The length of the hairs on the hind basitarsus of the male is rather constant. Only one male was found where the long hairs were as short as one-half the width of the basitarsal segment and in this case they originated close to the basal tuft with somewhat less space separating the tuft and the hairs than is normal [Arkansas, Malvern, VI-15-58 (25)].

The metasoma shows the usual color variation of other body regions. The first sternum of the male is variously tinted with green. Some specimens have the metallic nature barely visible [Louisiana, 2392 (9); several Minnesota specimens, etc.] whereas others are bright green or intermediate. In females the first sternum is not green although it may vary from light brown to dark brown and may be shiny and greenish but never metallic.

One male was found in which the second tergum is granulose and similar to the third rather than punctate as is the first [Missouri, Buffalo, VI-8-52 (20)]. The third tergum is frequently punctate like the first in females. In females the second tergum may be similar either to the first or third or even occasionally intermediate [Indiana, Tippecanoe Co., VI-16-53 (16)]. Again, this variation appears to be individual rather than regional in nature.

The color of pubescence in females varies regionally to a slight extent. In the eastern states (Georgia, Maryland, North Carolina, Virginia, Tennessee, Louisiana) the ventral part of the metasoma and basal segments of the legs have golden rather than white hair. In the midwest (Oklahoma, Wisconsin, Minnesota, Nebraska, Kansas, Missouri, Texas, Arkansas) most specimens are paler below with the hairs on the basal leg segments white and on the venter white or golden-white, although, in Iowa, Indiana, Oklahoma and Arkansas, individuals are variable so that all combinations can be found. One male was found that had all white pubescence [Illinois, "Airport Region" Peoria, VII-20-41 (14)].

On the male genital capsule, the inner lobe is variable and usually similar to that of *striata*. There is a tendency for the rounded portion to slope off sooner at each side of the apex, whereas in *striata* it is more broadly rounded. The finger-like process is variable in length although it is rarely as long as in *gratiosa* or *striata*.

Distribution. From the eastern Appalachian Mountains, Maryland to Georgia, westward to about the 97th parallel, from southeastern Minnesota and Wisconsin southward to northeastern Texas and Arkansas (Map: Fig. 90). Detailed data are omitted for areas where there are numerous localities (see Methods), but Figure 90 shows all localities.

More than 300 males and 2,300 females were seen: ALABAMA: *Cull-*

man Co., 1 ♂ (July); *Jefferson Co.*, 1 ♂ (August). ARKANSAS: (Fig. 90). GEORGIA: *Clark Co.*, 1 ♂, 1 ♀ (June); *Cobb Co.*, 1 ♀ (July); *Fulton Co.*, 3 ♂ (June); *McDuffie Co.*, 1 ♀; *Meriwether Co.*, 1 ♀ (July); *Polk Co.*, 1 ♀ (May); *Rabun Co.*, 1 ♂, 1 ♀ (June-July); "Head River" 1 ♀ (July). ILLINOIS: (Fig. 90). INDIANA: *Harrison Co.*, 1 ♀ (July); *Lake Co.*, 1 ♀ (August); *Spencer Co.*, 1 ♀ (September); *Tippecanoe Co.*, 6 ♂, 102 ♀ (April-September); *Warren Co.*, 1 ♂, 2♀ (July-August). IOWA: *Fremont Co.*, 1 ♀ (July); *Louisa Co.*, 1 ♀ (June); *Story Co.*, 5 ♀ (May). KANSAS (see Fig. 90). KENTUCKY: *Graves Co.*, 1 ♂ (June). LOUISIANA: *St. Landry Parish*, 1 ♂, 5 ♀. MARYLAND: *Montgomery Co.*, 6 ♀ (July). MICHIGAN: *Lenawee Co.*, 1 ♂ (September). MINNESOTA: *Fillmore Co.*, 2 ♀ (May); *Houston Co.*, 25 ♀ (May); *Le Sueur Co.*, 1 ♀ (August); *Olmsted Co.*, 1 ♂ (July); *Ramsey Co.*, 1 ♀ (May). MISSOURI (see Fig. 90). NEBRASKA: *Cass Co.*, 13 ♀ (May-July); *Douglas Co.*, 1 ♀ (August); *Lancaster Co.*, 1 ♀ (July); *Otoe Co.*, 4 ♀ (May, August); *Richardson Co.*, 1 ♀ (July); *Saunders Co.*, 5 ♀ (May); "Child's Point", 2 ♀ (July). NORTH CAROLINA: *Haywood Co.*, 1 ♂, 5 ♀ (May, July-August); *Rutherford Co.*, 1 ♀ (June); *Swain Co.*, 4 ♀ (April, June). OHIO: *Lawrence Co.*, 1 ♂, 1 ♀ (August); *Washington Co.*, 1 ♀ (June). OKLAHOMA (see Fig. 90). PENNSYLVANIA: *Delaware Co.*, 1 ♀ (June). SOUTH CAROLINA: *Greenville Co.*, 1 ♀ (August). TENNESSEE: *Knox Co.*, 1 ♂, 2 ♀ (May, August); *Lincoln Co.*, 1 ♀ (April); *Montgomery Co.*, 1 ♀ (July); *Sevier Co.*, 7 ♀ (July); *Shelby Co.*, 2 ♂, 7 ♀ (June). TEXAS: *Bowie Co.*, 3 ♀ (March); *Fannin Co.*, 2 ♀ (May); *Hunt Co.*, 7 ♀ (March-June); *Lamar Co.*, 1 ♂, 1 ♀ (June); *Nacogdoches Co.*, 2 ♂ (October); *Red River Co.*, 1 ♀ (April); *Tarrant Co.*, 1 ♂ (June). VIRGINIA: *Botetourt Co.*, 4 ♂, 3 ♀ (June); *Fairfax Co.*, 1 ♂, 14 ♀ (March, May-August); *Fauquier Co.*, 1 ♂, 2 ♀ (July); *Fredrick Co.*, 2 ♀ (May); *Prince William Co.*, 1 ♀ (July); "Barcroft", 11 ♀ (May-July, September). WISCONSIN: *Dane Co.*, 1 ♂, 12 ♀ (May-August); *Grant Co.*, 2 ♂ (July); *La Crosse Co.*, 1 ♀ (August); *Pierce Co.*, 1 ♂, 4 ♀ (July-August); *Vernon Co.*, 5 ♂, 3 ♀ (July-August); *Winnebago Co.*, 1 ♀ (August).

This species seems to be most common in eastern Oklahoma and Kansas, and throughout Arkansas, Missouri and Illinois. Although it does range east of the Mississippi River as far as the eastern slopes of the Appalachian chain, the populations apparently decrease in numbers. This is not entirely due to lack of collecting since ample specimens of *striata* have been obtained from many of these areas, but rather seems to reflect an actual thinning out of the species. One male was taken on the southern border of Michigan but specimens have not been taken further north in this state in spite of intensive collecting. South of Michigan the apparent gap could be due to inadequate

collecting in northeastern Indiana and northwestern Ohio. In the West, the abrupt line at about the 97th parallel reflects the decrease in rainfall and therefore corresponding changes in edaphic and vegetational conditions in this region.

Sandhouse (1937) limited the range of the species (using the name *aurata*) to south of 42 degrees north latitude even though she saw specimens from Minnesota, north of this line. Specimens recorded by her and others from Colorado and New Mexico are now recognized to be *striata* and *neglectula*. The Floridian specimens recorded by Sandhouse as *aurata* are the true *aurata* of Smith, 1853.

The distribution given by Mitchell (1960) was largely taken from the literature and reflects the complex errors in identification and synonymy. For example, J. B. Smith (1910) and Viereck (1916) record *"aurata"* and *"persimilis* (=*similis* Robt.)" from New York, New Jersey and Connecticut. It is uncertain what they were regarding as *aurata*, but their *persimilis* was undoubtedly the small *striata* form c that is occasionally found in these states or small individuals of other forms of *striata*.

The report by Rau (1922) concerning the nests of *A. similis* in a log refers to *Augochlora pura*. But perhaps the most complex error was made by Dreisbach (1945) who refers to "*Augochlorella neglectula* (=*A. aurata* Sm.)" as occurring in Michigan and gives as his reference Titus 1901, who referred to this species under the name *A. similis*. These specimens are not *aurata*, *neglectula* or *similis* (= *persimilis*) but are undoubtedly *striata*, essentially the only *Augochlorella* found in Michigan.

Seasonal Activity. *A. persimilis* is active from early April to about mid-October although nesting takes place only from the end of April to about the middle of August. Males start appearing with the emergence of the first brood at the end of May and can be found on flowers until the first frost in the fall. Although there is division of labor in colonies of this species, morphological castes cannot be distinguished. For details of the biology of *persimilis*, see Ordway (in press, a, b).

Flower Records. *Achillea, Agastache, Ailanthus, Alisma, Althaea, Ammannia, Amorpha, Antennaria, Anthemis, Aphanes, Apocynum, Arabis, Asclepias, Asparagus, Aster, Barbarea, Bidens, Blephilia, Borago, Brassica, Callirhoe, Camassia, Campanula, Capsella, Cardamine, Cassia, Ceanothus, Celastrus, Cerastium, Chrysanthemum, Chrysopsis, Cichorium, Cirsium, Citrullus, Claytonia, Convovulus, Coreopsis, Cornus, Cotoneaster, Crataegus, Cucurbita, Daucus, Descurainia, Diospyros, Echinacea, Erigeron, Erysimum, Eupatorium, Euphorbia, Fragaria, Geranium, Geum, Gnaphalium, Gutierrezia, Hedeoma, Helenium, Helianthus, Heliopsis, Heterotheca, Heuchera, Houstonia, Hypoxis, Ipomoea, Justicia, Kolkwitzia, Krigia, Lepidum, Lespedeza, Lippia, Lobelia, Lotus, Ludwigia, Lycopus, Malva, Medicago, Meli-*

lotus, Monarda, Nepeta, Nothoscordum, Oenothera, Oxalis, Paeonia, Parosela, Parthenium, Passiflora, Pastinaca, Petalostemum, Phacelia, Plantago, Polemonium, Polygonum, Polytaenia, Potentilla, Prunus, Psoralea, Pycnanthemum, Ranunculus, Raphanus, Rhus, Rorippa, Rosa, Rubus, Rudbeckia, Sabatia, Sagittaria, Salix, Salvia, Senecio, Sida, Silphium, Sisyrinchium, Smilacina, Smilax, Solidago, Specularia, Stellaria, Symphoricarpos, Taenidia, Taraxacum, Thaspium, Tradescantia, Trifolium, Valerianella, Verbena, Verbesina, Vernonia, Veronica, Virburnum, Zigadenus, Zizia.

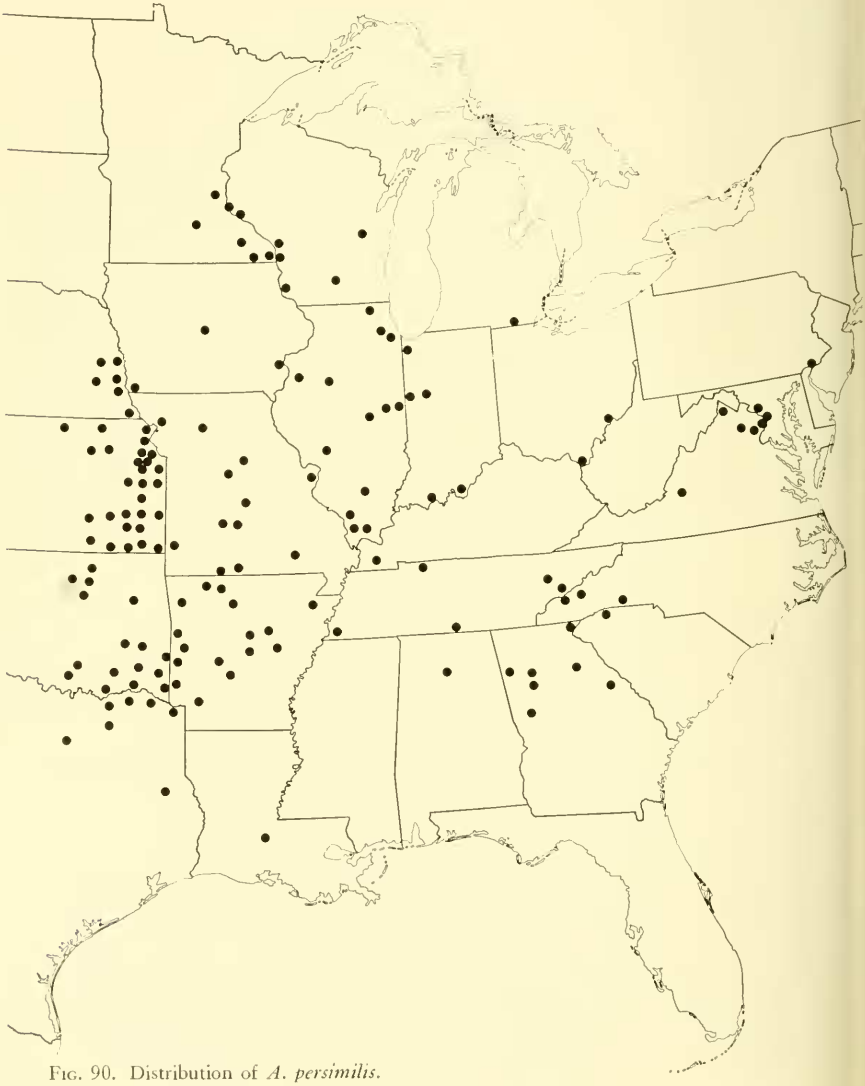

FIG. 90. Distribution of *A. persimilis.*

Augochlorella striata (Provancher)

Augochlora striata Provancher, 1888, Additions et Corrections au Volume II de la Faune Entomologique du Canada, traitant des Hyménoptères 2:317-318 (descr.); Dalla Torre, 1896, Catalogus Hymenoptorum 10:96 (list); Procter, 1938, Biological Survey of the Mount Desert Region, part VI, p. 443 (list); Procter, 1946, Biological Survey of the Mount Desert Region, part VII, p. 506 (list); Evans & Lin, 1959, Wasmann Jour. Biol. 17:120, 123, 127, 131 (biol.).

Augochlorella striata: Sandhouse, 1937, Jour. Washington Acad. Sci. 27:70 (tax.); Procter, 1938, Biological Survey of the Mount Desert Region, part VI, p. 443 (list); Lovell, 1942, Kentucky Acad. Sci. Trans. 10:20-22 (key, descr.); Dreisbach, 1945, Michigan Acad. Sci. Arts and Letters, paper 30, p. 225 (distr.); Procter, 1946, Biological Survey of the Mount Desert Region, part VII, p. 506 (list); Moure, 1950, Dusenia 1:310 (key); Stephens, 1951, North Dakota Agr. Exper. Sta. Bull. 14:63 (list); Mitchell, 1960, Bees of the Eastern United States 1:461 (tax.); Michener & Wille, 1961, Univ. Kansas Sci. Bull. 42:1130 (biol.); Knerer & Atwood, 1962, Proc. Ent. Soc. Ontario 92:174 (dist., fl., biol.); Sakagami & Michener, 1962, Nest Architecture of Sweat Bees 1-135 pp. (biol.); Eickwort & Fisher, 1963, Ann. Ent. Soc. Amer. 56:350 (descr.); Ordway, 1964, Jour. Kansas Ent. Soc. 37:139-152 (biol.); Judd, 1964, Canad. Ent. 96:1475 (fl.); Evans, 1964, Psyche 71:142, 147 (biol.); Michener, 1964, Am. Zool. 4:233 (biol.); Ordway, 1965, Insectes Sociaux 12:291-308 (biol.); Ordway, in press, Jour. Kansas Ent. Soc. (biol.).

Augochlora (Augochlorella) striata: Michener, 1951, *in* Muesebeck, *et al.* U.S. Dept. Agr., Agr. Monogr. 2:1126 (list); Montgomery, 1957, Proc. Indiana Acad. Sci. 66:132 (list, fl.).

Augochlora matilda Robertson, 1893, Trans. Amer. Ent. Soc. 20:147 (descr.); Dalla Torre, 1896, Catalogus Hymenoptorum 10:95 (list); Cockerell, 1922, Proc. U.S. Nat. Mus. 60:16 (list).

Augochlora confusa Robertson, 1897, Trans. Acad. Sci. St. Louis 7:324 (descr.); Bridwell, 1899, Trans. Kansas. Acad. Sci. 16:210 (list); Cockerell, 1899, Ent. News 10:3 (list); Titus, 1901, Canad. Ent. 33:134 (descr.); Cockerell, 1902, Amer. Nat. 36:811, 816 (descr., biol.); Cockerell, 1906, Trans. Amer. Ent. Soc. 32:295 (list); Lovell, 1908, Psyche 15:40 (list); Cockerell, 1911, Canad. Ent. 43:391 (list); Graenicher, 1911, Bull. Public Mus. Milwaukee 1:234 (list); Crawford, 1913, Canad. Ent. 45:271 (list); Cockerell, 1915, Pomona Jour. Ent. Zool. 7:232 (descr.); Stephens, 1921, Canad. Ent. 53:68 (list); Rau, 1922, Trans. Acad. Sci. St. Louis 24:32 (biol.); Hendrickson, 1930, Iowa State Coll. Jour. Sci. 4:162 (list); Phillips, 1933, Jour. Agr. Res. 46:860 (list); Michener, 1937, Ann. Mag. Nat. Hist. (10)19:314 (descr.); Brimley, 1938, Insects of North Carolina p. 455 (list).

Augochlora (Oxystoglossa) confusa: Robertson, 1902, Canad. Ent. 34:247 (key).

Oxystoglossa confusa: Hart & Gleason, 1907, Bull. Illinois State Lab. Nat. Hist. 7:256 (list); Robertson, 1928, Flowers and Insects pp. 1-221 (fl., list); Pearson,

1933, Ecol. Monogr. 3:386, 396, 416, 417 (biol.); Procter, 1938, Biological Survey of the Mount Desert Region, part VI, p. 443 (list).

Halictus (Oxystoglossa) confusus: Viereck, 1916, Connecticut Geol. Nat. Hist. Survey Bull. 22:701, 703, 705 (key, list); Britton, 1920, Connecticut Geol. Nat. Hist. Survey Bull. 31:342 (list); Leonard, 1926, Cornell Univ. Agr. Sta. Mem. 101:1025 (list).

Augochlora coloradensis Titus, 1901, Canad. Ent. 33:133 (descr.); Cockerell, 1911, Canad. Ent. 43:390 (list); Hicks, 1931, Canad. Ent. 63:176 (biol.); Cockerell, 1934, Amer. Mus. Novitates 697:1 (list).

Augochlora confusa coloradensis: Cockerell, 1906, Trans. Amer. Ent. Soc. 32:295 (list); Cockerell, 1907, Univ. Colorado Studies 4:243 (list); Cockerell, 1915, Ann. Mag. Nat. Hist. (8)15:269 (descr.); Cockerell, 1928, Univ. Colorado Studies 16:101 (list).

Augochlora pseudopurella Strand, 1914, Archiv. Naturg. 80:163 (list).

Augochlora aurata: Evans & Lin, 1959, Wasmann Jour. Biol. 17:120, 123, 131 (biol.).

Augochlora pura: Robertson, 1893, Trans. Amer. Ent. Soc. 20:146; Robertson, 1894, Trans. Acad. Sci. St. Louis 7:436-480 (in part) (fl.) (misidentifications).

Augochlora neglectula: Titus, 1901, Canad. Ent. 33:134; Cockerell, 1928, Univ. Colorado Studies 16:101; Dreisbach, 1945, Michigan Acad. Sci. Arts & Letters, paper 30, p. 225 (misidentifications).

Augochlora similis: Titus, 1901, Canad. Ent. 33:134 (misidentification).

Oxystoglossa similis: Britton & Viereck, 1906, *in* 29th Ann. Rept. Connecticut Agr. Exper. Sta., New Haven, 1905, part 4, p. 212 (misidentification).

Halictus (Oxystoglossa) persimilis: Viereck, 1910, *in* Smith, Ann. Rept. New Jersey State Mus. 1909:688; Viereck, 1916, Connecticut Geol. Nat. Hist. Surv. Bull. No. 22, 5:701, 703, 705; Britton, 1920, Connecticut Geol. Nat. Hist. Surv. Bull. No. 31, p. 342 (misidentifications).

Halictus (Augochlora) auratus: Viereck, 1910, *in* Smith, Ann. Rept. New Jersey State Mus. 1909, p. 688 (misidentification).

Halictus (Oxystoglossa) purus: Vachal, 1911, Misc. Ent. 19:50, 53, 111 (misidentification).

Types. Augochlora striata, female lectotype, male lectoallotype, from Quebec, Canada, are in the collection of Laval University, Department of Biology, Ste. Foy, Quebec, Canada. These specimens have been carefully compared by Dr. René Beiqué, Curator of Entomology at Laval University, with specimens I submitted. Dr. Beiqué's careful examination and illustration clearly show that these specimens are typical of *striata* of eastern Canada and typify form A of the discussion below. According to Dr. Beiqué (personal communication), these types are the only two specimens of this species in the Provancher collection, although the original series contained two females and four males. The lectotypes were labeled (but not published) by Mr. Noel Comeau, the former curator of the Provancher collection, in 1941, and are labeled as follows: female specimen No. 119: with a small yellow

label marked 1475 (Provancher number), a white label with red border bearing the identification in Provancher's handwriting, a red label marked lectotype with the identification, Comeau's signature, dated 1941 and No. 119; male specimen No. 120: with a small white label with ♂ sign, a yellow label with Provancher's number 1475 A, and a purple label marked Allotype, No. 120, with Comeau's signature and dated 1941. The lectotype designation is here published for the first time. The location of the rest of the syntype series is not known.

Augochlora confusa, lectotype female No. 927 (Robertson's number) is from Carlinville, Macoupin Co., Illinois, 1886, and is in the Robertson Collection at the Illinois Natural History Survey. This specimen was selected from among 33 females of *Augochlorella striata* in the syntype series. Eighteen other females in the series are *Augochlora pura*. I have also seen seven male syntypes, all *striata*, and similar in appearance. I have not seen one female and four males of the original species. It seems certain that Robertson's description was based upon the *Augochlorella striata* and not the *Augochlora pura*. This lectotype designation is also published here for the first time.

Augochlora coloradensis, lectotype female, Ft. Collins [Larimer Co.], Colorado, June 13, 1899, is at the U.S. National Museum. It has a red U.S. National Museum cotype label No. 19459, and an identification label by Titus. I have selected this specimen as the lectotype because it agrees as well as any with the description, is in good condition, and will be located at the same museum as other Titus types. Other known female syntypes are located at the Museum of Comparative Zoology (1 specimen), U.S. National Museum (1 other specimen), Purdue University (2 specimens), University of Kansas (1 specimen), and Colorado State University (6 specimens). This species was originally described from numerous females and two males. I have not seen the males or other females, if any.

Augochlora matilda, lectotype female, No. 12247 (Robertson's number), from Inverness, Citrus Co., Florida, 1892, is in the Robertson Collection at the Illinois Natural History Survey. I have seen only one of the two syntypes and here designate it as the lectotype.

Augochlora pseudopurella Strand was proposed for *Halictus purus* Vachal (not Say). It does not seem likely that Strand designated a holotype from among the "numerous" specimens which Vachal misidentified as *H. purus* Say. I have not seen these specimens which are in the Museum National d'Histoire Naturelle de Paris, but Pe. J. S. Moure (personal communication) has verified that they are *Augochlorella* and not *Augochlora*. The specimens from Canada, the northeastern United States and possibly Louisiana would be *striata*; those from Orizaba and Oaxaca, Mexico, are probably *neglectula*.

This species consists of highly variable, intergrading groups of individuals. In order to describe and discuss the variation, four forms (A-D) have been recognized. The variability is such over most of the range that no definite line can be drawn between the four groups and therefore it is not always possible to assign certain specimens to any of the groups. These unplaced individuals are called "s". Although detailed studies were made of variations among the males, it seemed impractical to characterize the forms, so that many of the males are therefore assigned to group s. The following discussions of the forms concern only females unless specific reference is made to males. Biological information from Kansas (see Biosystematics) indicates that there may be at least two populations or species, but until further ecological and behavioral data are obtained, there is little justification for recognizing more than one species. However, when possible, I have kept the information concerning the four groups separated in the following discussion and records, in the event that further biological work substantiates the hints that there may be sibling species involved.

In discussing regional variation among the different forms, the specimens are compared with a standard." This is a specimen of each form chosen from an area where the form is usually distinct, where there are few, if any, intergrades, and where the majority of specimens look alike. The term "standard" refers *only* to these specimens in the following discussions. The standard of form A is from Philadelphia, Pennsylvania, IX-24-14 (38); that of form B is from Alleghany Co., North Carolina, along Little River, nr. Eunice, VIII-26-28-57 (R. Baileys & C. F. Walker) (25); that of form C is from Lee Co., Iowa, VI-28-29- (Parks) (6); and that of form D is from Colorado Springs, Colorado, VI-6-52 (W. E. LaBerge) (20).

The type of *striata* is form A. Robertson's *matilda* is also form A but is too coarsely sculptured to be typical except in Florida. The type of Robertson's *confusa* is typical of form C. Form B is morphologically between A and C. In some areas it intergrades with form A, in other areas with form C. Occasionally there is a continuum from A to C but usually B is entirely separable from both A and C. The type of *coloradensis* Titus is a representative of form D. In some areas this form appears to be a variable intergrade between A, B and C but in other areas it is quite distinct.

The following descriptions apply to all forms of *striata* except as noted.

Description. Female: (1) Length 5 to 8 mm; head width 1.55 to 2.82 mm, averaging 1.96 mm, width greater than length. (2) Color varying regionally from blue-green to yellow-green; frons without bluish reflections in green specimens; metasoma similar in color to head and thorax. (3) Mandible with basal third dark brown, reddish brown centrally, rufous at tip; without green reflections basally. (4) Clypeal length equal to, or slightly greater than width; basal part green with large, irregularly spaced punctures.

smaller and closer basally; apical one-fourth to one-half brown, slightly beveled, with elongate punctures or irregularities; surface between punctures smooth and shiny. (5) Supraclypeal area variously punctate with surface between punctures smooth or roughened. (6) Paraocular area punctorugose to rugose below antennae, coarsely rugose above antennae. (7) Antenna dark brown, flagellum slightly lighter below than above, pedicel as long as broad, first flagellar segment slightly wider than long; pedicel longer than but equal in width to first flagellar segment. (8) Scutum coarsely punctate to rugose (some form A only) medially, becoming more coarsely rugose between parapsidal lines; anterior margin smoothly roughened at midline, becoming coarsely areolate laterally. (9) Tegula about 1.5 times as long as wide. (10) Scutellum finely and irregularly roughened, without distinct punctures. (11) Pleuron rugose, becoming areolate anteriorly. (12) Propodeum with disc variable in size, shape and sculpturing; length equal to metanotum (some form A) or more usually, longer than metanotum, rarely more than twice metanotal length; outline of disc sharply to roundly bracket-shaped (forms A, D) to deeply roundly or obtusely V-shaped (forms A, B) to broadly U-shaped or semicircular (form C), profile types 1-4; posterior edge sharp or weakly carinate (form A), abruptly rounded and thickened (forms B, D) to smoothly and gradually rounded and indistinct (form C); striae usually distinct, slightly irregular or straight, usually reaching edge posteriorly; posterior vertical surface coarsely and deeply roughened (some form A only) to smooth, shiny and granular; posterolateral corners finely granular to finely roughened (forms B, C, D), to strongly roughened (forms A, B) or rugose (form A); lateral vertical surface finely to coarsely (some form A only) rugose or reticulated. (13) Legs brown; coxae bright green, trochanters and femora usually with weak metallic reflections. (14) Metasomal terga with apical margins narrowly, often inconspicuously margined with brown; first tergum with anterior portion polished, sparsely and finely punctate, dorsal surface variously punctate with punctures minute and inconspicuous to large, and widely to closely, regularly to irregularly spaced; second tergum with punctures similar to first but with punctures closer; first metasomal sternum with or without weak metallic reflections. (15) Pubescence golden on dorsum and legs and ventrally on metasoma; golden to white ventrally on thorax and head.

Male: (1) Length 6 to 8 mm; head width 1.63 to 2.13 mm, averaging 1.85 mm, usually equal to or less than length, rarely wider than long. (2) Color yellow-green to dark blue-green, usually bright shiny green, frons without blue reflections on green specimens, usually uniformly colored over entire body. (3) Mandible with or without metallic reflections basally. (4) Clypeus with punctures variables in size and number, separated by about their own diameters, surface between punctures usually smooth and shiny. (5) Supra-

clypeal area protuberant, variably punctate, with surface between punctures roughened or somtimes smooth and shiny at least basally. (6) Paraocular area with small close punctures below level of antennae, minutely but deeply punctorugose above level of antennae. (7) Flagellum dark brown above, yellow-brown below; scape and pedicel dark brown with yellow apical area below; width of pedicel and first flagellar segments variable, each averaging 1.5 times as wide as long. (8) Scutum shiny with punctures variable in size and spacing; anterior margin and anterolateral angles areolate, smoother anteromedially. (9) Tegula about two times longer than wide. (10) Scutellum with surface irregular, punctate to rugose; punctures, when present, distinct to indistinct, irregular in size and spacing. (11) Pleuron punctate to rugose, becoming areolate anteriorly. (12) Propodeum with disc equal to or slightly longer than metanotum; outline of disc varying from distinctly bracket-shaped to obtusely U-shaped or semicircular, posterior edge varying from sharply angulate and prominent to gradually rounded; striae fine to coarse, regular to irregular or branched, straight to wavy, widely separated to close together, usually reaching edge posteriorly, or slightly before when edge of disc gradually rounded, reaching edge laterally; posterior vertical surface minutely to finely rough; posterolateral corners with or without subhorizontal rugae extending from lateral to posterior faces; lateral vertical surface irregular, rugose with weak lineate rugae perpendicular to anterior and ventral edges. (13) Legs brown, fore and hind coxae, trochanters and femora green, tibiae dark brown, with greenish reflections at least on anterior side of hind leg, usually yellow-brown apically and basally; tarsi brown; hind basitarsus with erect hairs of uniform length, equal to or longer than basal hairs, length variable, not exceeding 1.5 times width of segment; basal tuft present. (14) Metasomal terga green with brown apical margins; first tergum polished with widely scattered, fine punctures anteriorly, smooth but less shiny dorsally, punctures variable in size and spacing; second tergum with punctures variable in size, denser than those of first, indistinct on third and following terga, surface minutely reticulated in appearance, pubescence fine, short to long depending on wear; first sternum usually with metallic reflections variable in intensity; fourth sternum distinctly but weakly emarginate. (15) Pubescence white to golden, usually golden dorsally, white ventrally with long golden hairs and short white hairs on head and ventral part of abdomen; golden on tibiae and tarsi, white on coxae, trochanters and femora. (16) Genital capsule, sterna 7 and 8 and tergum 8 of type 1 (Figs. 32, 40, 43).

Forms

The following accounts describe the "standard" individual of each form and a series from the same locality. They do not include total variation of

the form or attempt to describe intergrades among the forms. The males were described only from specimens that could be definitely placed as to form and were usually from the same areas as the females.

A. striata form A

Female: Disc sharply bracket-shaped to obtusely V-shaped (Figs. 59, 60), shorter to slightly longer than metanotum, these sclerites usually about equal in length; length of disc at posterolateral corners as long as length posteromedially; edge of disc weakly carinate to sharply defined posteriorly (Fig. 21), becoming rounded laterally; disc pointed or sharply V-shaped medially and depressed onto posterior vertical surface. Striae variable, straight, thick and well defined to irregular, branched and close, or thin, fine and very close; always reaching well defined edge. Posterior vertical surface of propodeum smoothly granular to coarsely roughened or rugose.

Male: Disc usually as long as metanotum or only slightly longer, with distinct, usually sharp edge, often bracket-shaped; striae well defined, regular but wavy, reaching edge; posterior surface of propodeum variable, usually uneven, may be rather smooth to rough. Hind basitarsus with hairs appearing short and sparse, only slightly longer than width of basitarsus, contrasting only slightly in length with basal tuft.

All *striata* with sharp bracket-shaped discal areas belong in this group. As the bracket-shape and edge become rounded it is less easy to recognize this form. This form grades gradually into forms B, C and D as the disc becomes more rounded in shape and rounded along its edge. The outline of the disc is similar to that of *gratiosa* and females may look similar to *gratiosa* and *aurata* when the striae are fine.

A. striata form B

Female: Disc longer than metanotum, up to twice as long, obtusely V-shaped, longer medially than laterally, with medial portion of V rounded and sometimes extending onto posterior vertical surface (Fig. 63), edge distinct, often thickened, rough and abrupt but rounded (Fig. 23), not ridged or carinate. Striae large, irregular and branched, reaching edge at all points; posterior vertical surface of propodeum finely and regularly granular (Fig. 74), lateral vertical surface rugose.

Male: Disc long medially, obtusely V-shaped, up to twice as long as metanotum, with edge thickened but rounded and often roughened; striae wavy but regular, reaching edge; posterior surface of propodeum usually shiny but rough to smooth, punctured or finely rugose, variable throughout range; hind basitarsal hair dense, usually of more or less uniform length,

about twice as long as basal tuft; hind basitarsus usually appearing large, with long, dense hair.

These bees are usually large and light green. They grade into forms A, C and D in certain areas but are predominant and most similar to the standard in the southeastern part of the range.

A. striata form C

Female: Disc large, up to twice length of metanotum, broadly U-shaped (Fig. 62); edge of disc indistinct, smoothly and gradually rounded from vertical to horizontal plane; striae large and distinct, straight or irregular, wavy and branched, sometimes widely separated; striae ending gradually at indistinct edge of disc; surface between striae shiny and smooth or minutely reticulated or minutely roughened; posterior vertical surface of propodeum evenly granular (Fig. 74), lateral vertical surface rugose.

Male: Disc broadly and deeply U-shaped, longer than metanotum; edge of disc smoothly rounded, shiny; striae straight, often widely separated with surface shiny between, usually reaching edge or ending gradually just before edge; posterior surface of the propodeum shiny but uneven or roughened and irregularly and minutely punctured, often rough; hind basitarsus with hairs long but sparse, distinctly longer than basal tuft.

There is wide variation in size in this form but the most distinctive or characteristic bees of this group are large. Small individuals look similar to *A. persimilis*, especially if the striae fade out before the edge of the disc leaving a shiny area between the striae and the edge. These bees are most prevalent in the northern part of the range and are most similar to the standard in Iowa and Illinois.

A. striata form D

Female: Propodeal disc equal to or usually slightly longer than metanotum, obtusely U-shaped to weakly bracket-shaped (Fig. 71), edge distinct, often slightly thickened and rough or uneven, sometimes extending medially onto posterior surface as indistinct or rounded V; striae large, irregular or vermiform, usually reaching edge posteriorly; posterior vertical surface of propodeum smooth and finely granular (Fig. 74); lateral vertical surface coarsely reticulate to rugose.

Male: Disc similar to those of female but with smoother, rounded posterior edge and often straighter striae; edge slightly extended medially but rounded rather than V-shaped; posterior vertical surface of propodeum shiny, shallowly punctured to weakly rugose, finely and linearly rugose or punctorugose over posterolateral corners and on lateral vertical surface;

hairs of hind basitarsus less than twice as long as width of segment but appearing long, rather dense and distinctly longer than basal tuft.

These bees are usually bright green to dark green. They intergrade with forms A, B and occasionally with C. They are predominant and most similar to the standard in the western part of the range from Texas to the Dakotas.

Comparisons. A. striata is the most widely distributed and morphologically diverse of all the North American species of *Augochlorella*. It overlaps the ranges of all the species north of Mexico except *pomoniella* and intergrades morphologically, at least in the females, with these species. It frequently is the largest and most coarsely sculptured of the eastern species but due to the wide variability in size, cannot always be distinguished by these features.

In the southeastern region most specimens of *striata* are distinctive although gradations toward *aurata* and *persimilis* do exist. Males of *striata* A, in particular, are easily confused with those of *aurata*, and although the key separates the two, without biological information I am uncertain whether the separation represents a valid difference between populations or merely an artificial or arbitrary dichotomy. Females of *striata* A may be separated from *aurata* and *gratiosa* where ranges overlap by their generally coarser striae, the rougher sculpturing and other key characters.

A few specimens in the south and southeast and many in the central region that are small individuals of *striata* C or possibly D, intergrade completely with *persimilis*, so that differentiation of females cannot always be certain. In these individuals the body size, the characters of the disc, and the body sculpturing all resemble those of *persimilis*.

In Texas, some *striata* D may resemble *bracteata* in the characters of the disc but in this region most *striata* are larger and more rugose than *bracteata*, and the two species should not be confused.

There seems to be little if any intergradation with *neglectula* where the ranges overlap in southeastern New Mexico. *A. striata* (mostly D) are usually less rough on the posterior vertical surface of the propodeum than *neglectula* and can be easily separated by the key characters.

Variation (all forms). Body size and head width in both males and females varies considerably throughout the range (Fig. 86), with the largest specimens (8 mm) occurring among Floridian specimens of form A and the smallest (6 mm) among New Mexican specimens of form D. Small worker-like individuals were found in all forms usually during summer months, the small individuals of form C usually intergrading with, or becoming indistinguishable from, *persimilis*.

Body color varies regionally in both sexes with dark blue-green individuals found chiefly in Florida and New Mexico. Elsewhere, throughout the range, most specimens are a bright green but may range from yellow-green to blue-

green. The different regions of the body of any one specimen are similar in coloration, so that *striata* is more uniform in color than other eastern species. The mandibles of females are usually brown as described; however some Floridian specimens do have weak greenish reflections at the bases.

The supraclypeal area in both sexes is variously punctate. In females, the surface between punctures is usually shiny and smooth but may be minutely roughened or weakly rugose as in some Floridian specimens. In males, the supraclypeal area is roughened but may be smoother basally than just below the antennae.

The punctation patterns on the scutum of males can be divided into four groups, all groups occurring throughout the range but with one pattern often regionally predominant. This character appears to be more geographically variable than it is variable among forms and cannot be correlated with any of the other major characters. The following puncture patterns can be recognized: a) Punctures distinct and widely spaced centrally, separated by distances equal to or greater than one diameter; closer laterally, distinct to almost contiguous at the parapsidal lines. b) Evenly and widely spaced (separated by two times their diameters) over entire scutum. c) Evenly and closely spaced (separated by distances, equal to or less than their own diameters) over entire scutum. d) Distinct but unevenly spaced medially, becoming very close and rugose just medial of the parapsidal lines. No such variation is found in females.

Males are less easily separated into forms than females on the basis of propodeal characters and show a wider range of variation so that in certain areas each of a number of individuals has a different combination of characters (Florida, Kansas, Nebraska, etc.). Deviations from the descriptions of the four forms occur among the intergrades between different forms and among intergrades of *striata* and other species but it is not feasible to describe all the variations found in the continuum.

The legs show little color variation; paler specimens show less metallic coloration than darker ones. In males, the extent of metallic coloration on the outer surface of the hind tibia is individually variable. The hairs on the hind basitarsus of males, although similar in length for all forms, look longer and denser in form B with the hairs of the basal tuft appearing proportionally shorter than in forms A, C and D. Although differences do exist in these characters, they form a continuum and cannot be correlated with other characters.

The metasomal punctures are variable in size and spacing in both sexes, but like scutal punctures can be divided into groups. Any one group may be regionally predominant (Indiana, Illinois, Michigan, etc.) or the punctation may vary among individuals within any one region (Nebraska, Minnesota, Texas, Connecticut, etc.). In males the punctures are always distinct, al-

though regularly or irregularly spaced and separated by more than to less than their own diameters. In the females the punctures are frequently very small or inconspicuous but may also become large. Spacing varies from very close to widely scattered and regularly or irregularly spaced. Not all specimens show the greenish reflections on the first sternum, and in those that do, the amount or intensity is variable. This coloration occurs more often in males than in females, and there seems to be no correlation between this character and the form or region.

Distribution. Southern Canada to southern Florida, westward to the Rocky Mountains. More than 6700 females and 1400 males were seen. Due to the abundance of this species throughout its range, locality data are indicated only by Figure 91 (see Methods).

Seasonal Activity. A. striata is active from early April to about the middle of October throughout most of its range. Pollen collectors are found from the end of April through middle or late August and males occur from late May to late October. In the North the season is slightly shorter, lasting from the end of April to the end of September, whereas in the South the bees are active throughout the year with pollen collectors being found from early April to early September.

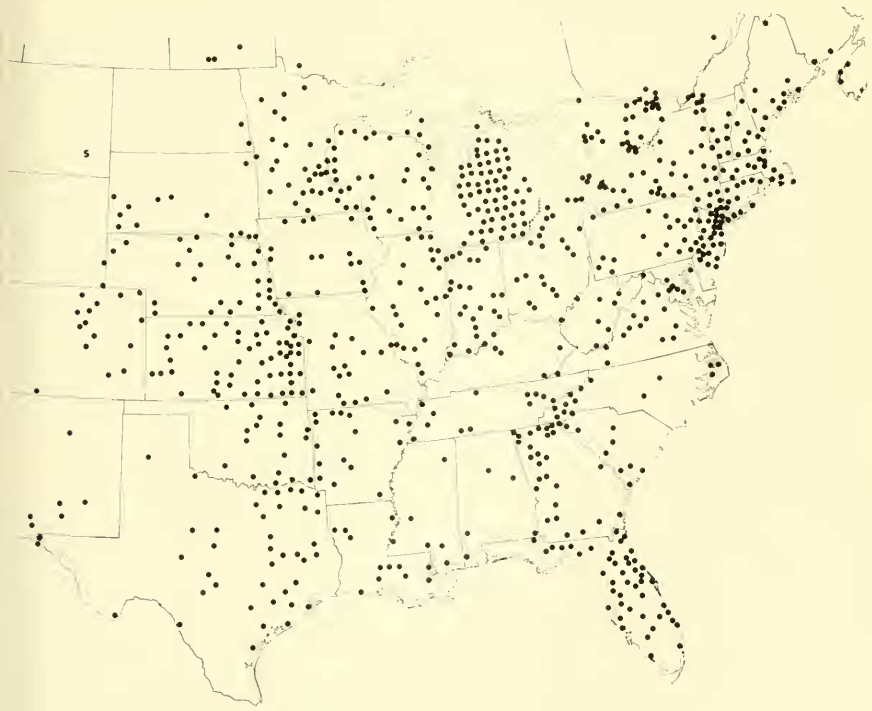

FIG. 91. Distribution of *A. striata.*

There is considerable variation in size in this species (Fig. 86) within all forms. Usually the small individuals are similar in structure and appearance to the larger females of the same form although somewhat less coarsely sculptured. There is a queen and usually one or more workers (individuals that do not lay eggs) in each nest, but these cannot always be distinguished morphologically. Where both large and small individuals are present in one nest, one of the large females is always the queen and the remaining large and small females are workers. All gradations in size may occur within one colony, or all bees of a colony may be approximately the same size. Small individuals (probably of form c) do sometimes found nests in the spring, but then all offspring are as small as the queen or smaller. For further details on the biology of this species, see Ordway (1965a; in press).

Flower Records. Achillea, Aesculus, Agastache, Agoseris, Althaea, Amelanchier, Amorpha, Anemone, Anemonella, Antennaria, Apocynum, Aqui-

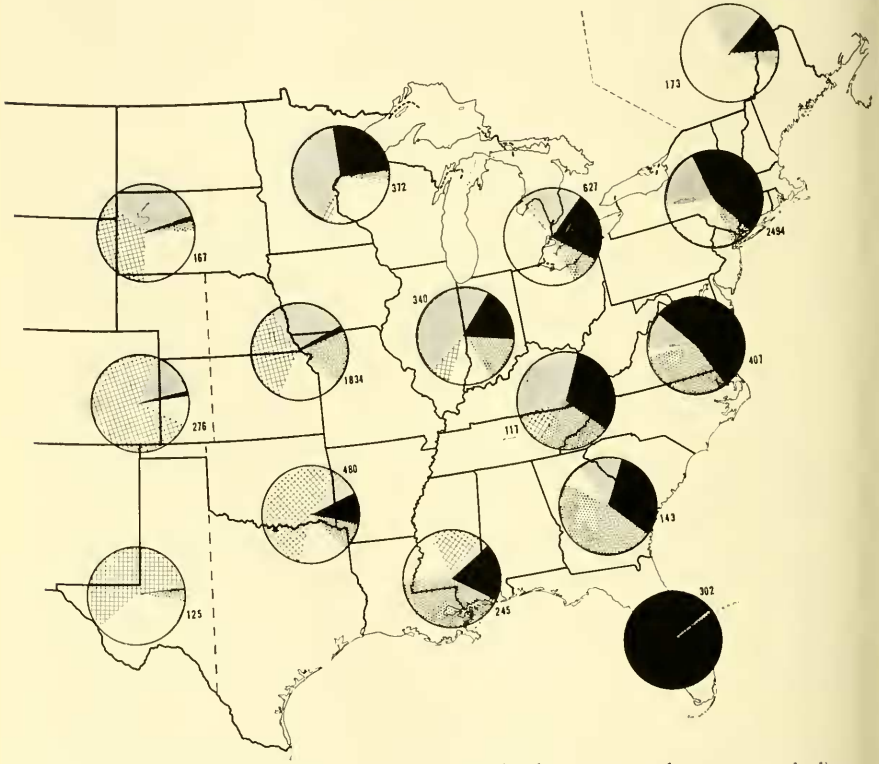

FIG. 92. Distributions of forms of *A. striata*. (Black—form A; dots—form B; gray shading—form C; cross-hatched—form D; white—group S.)

Each circle includes each state it overlaps except where the state is divided by broken line. Circle No. 117 includes West Virginia, Kentucky, Tennessee only. Circle No. 276 does not include New Mexico. The numbers beside each circle represent the total number of specimens examined from the area represented by the circle.

legia, Arabis, Aralia, Argemone, Aruncus, Asclepias, Aster, Astragalus, Barbarea, Berteroa, Bidens, Brassica, Callirhoe, Calopogon, Camassia, Camelina, Campanula, Capsella, Cardamine, Carduus, Cassia, Caulophyllum, Ceanothus, Celastrus, Centaurea, Cephalanthus, Cercis, Chaerophyllum, Chrysanthemum, Chrysopsis, Cichorium, Cicuta, Circaea, Cirsium, Citrullus, Claytonia, Clethra, Convovulus, Coreopsis, Cornus, Crataegus, Crypthantha, Cryptotaenia, Cubelium, Cucumis, Cucurbita, Cunila, Daucus, Dentaria, Diervilla, Dodecatheon, Echinacea, Echium, Ellisia, Erigenia, Erigeron, Erysimum, Euonymus, Eupatorium, Euphorbia, Fragaria, Gaillardia, Geranium, Gerardia, Glechoma, Gnaphalium, Gossypium, Grindelia, Gutierrezia, Haplopappus, Hedeoma, Heiracium, Helenium, Helianthus, Heliopsis, Heracleum, Heterotheca, Heuchera, Hieracium, Houstonia, Hybanthus, Hydrangea, Hydrocotyle, Hydrolea, Hydrophyllum, Hypericum, Impatiens, Inula, Ipomoea, Iris, Isopyrum, Kolkwitzia, Krigia, Lactuca, Lathyrus, Lepidium, Lespedeza, Lesquerella, Linum, Lippia, Lobelia, Lomatium, Lonicera, Lotus, Lycopersicum, Lycopus, Lythrum, Malus, Malva, Medicago, Melilotus, Mentha, Mertensia, Mikania, Monarda, Myosoton, Nigella, Nothoscordum, Oenothera, Onopordum, Opuntia, Osmorhiza, Oxalis, Paeonia, Parthenium, Parthenocissus, Paspalum, Pastinaca, Penstemon, Perideridia, Petalostemum, Phryma, Physalis, Polemonium, Polygonatum, Polygonum, Polymnia, Polytaenia, Pontederia, Potentilla, Prenanthes, Prunella, Prunus, Psoralea, Ptelea, Pteridium, Pycnanthemum, Pyrrhopappus, Pyrus, Ranunculus, Ratibida, Rhamnus, Rhus, Ribes, Rorippa, Rosa, Rubus, Rudbeckia, Sagittaria, Salix, Salvia, Sanicula, Sapindus, Satureja, Scrophularia, Scutellaria, Sedum, Senecio, Sericocarpus, Sida, Silphium, Sisymbrium, Sisyrinchium, Smilacina, Smilax, Solanum, Solidago, Sonchus, Specularia, Sphaeralcea, Spiraea, Stellaria, Stokesia, Strophostyles, Symphoricarpos, Syringa, Taenidia, Tanacetum, Taraxacum, Teucrium, Thaspium, Tradescantia, Tragopogon, Trifolium, Trillium, Triosteum, Vaccinium, Verbascum, Verbena, Vernonia, Viburnum, Vicia, Viola, Vitis, Waldsteinia, Xanthoxylum, Zizia.

BIOSYSTEMATICS OF *A. STRIATA* AND *PERSIMILIS*

The biology of *persimilis* and *striata* is discussed in detail by Ordway (1965a; in press). Some of the results obtained by excavating 133 nests near Lawrence, Kansas, are of systematic importance and are discussed here since populations from these nests shed some light on the complexities of the interspecific and intraspecific variation. Except as otherwise indicated, the following discussion relates only to females.

About 21% of the nests contained unquestionable *persimilis*; 54% were clearly *striata* (*s.l.*) and 25% contained apparent mixtures of *persimilis* and

striata or individuals of uncertain identity intermediate between the two species.

The 72 nests of *striata* contained pure colonies of forms B, C, or D individuals, or mixed colonies of both B and D individuals, mixed colonies of B-C or B-D intermediates or more usually, mixtures of B and B-C, B and B-D or C and C-D individuals. One nest was found to contain A-D intermediates. There were six nests containing recognizable *striata* of forms B, C, D, or their intermediates, as well as small, *persimilis*-like individuals, but in all cases the small individuals looked more like small *striata* C than like *persimilis*. In contrast, two nests were found with small but clearly *striata*-like females as well as males of *persimilis*.

Of the 25 nests containing *persimilis-striata* mixtures or intermediates, 20 contained individuals intermediate between *persimilis* and *striata* and five contained apparent mixtures of both *persimilis* and *striata*. None of these nests contained males.

Since males of *striata* and *persimilis* are easily distinguished, 30 females intermediate between the two species were brought into the laboratory and allowed to establish nests. Male progeny from these females were examined after they emerged from the nests or as they were leaving. Of the 116 males recovered throughout the summer, 94% were *persimilis*, indicating that most of the original females belonged to this species. Judging by the frequency and periodic appearance of the *striata* males, it appeared probable that they were produced by a single female.

Although these data are fragmentary, they do serve to crystallize some of the problems involved. Within the species *striata*, it seems that forms B and D are not different biologically since both can be regularly found within a single nest population. Form C may be biologically distinct since no nests were found in which both C and another form coexisted, although C-D intermediates occur in nests with form C.

The small specimens, intermediate between *striata* and *persimilis* that were found within the *striata* nests, were probably *striata*, and those in nests of *persimilis* were probably *persimilis* although the possibility that F_1 hybrids exist cannot be ignored. Male (presumably haploid) offspring of both *striata* and *persimilis* are produced by the intermediate females but it has not been established if any one female can produce both.

So far, biological, behavioral or ecological differences have not been found between the forms of *striata* as they occur in eastern Kansas and such differences between the two species are only slight if extant. If significant differences are discovered or if methods could be found to keep progeny of various females segregated in the laboratory, it would be worth the time and effort to examine in much greater detail the interspecific and intraspecific variation in an attempt to define or categorize those individuals now being

Table 2. Per Cent Occurrence of Species of *Augochlorella* from Each Area.

Area	% striata	% gratiosa	% persimilis	% bracteata	% aurata	% neglectula	% pomoniella	% edentata	Total Augochlorella
Northeast	99.9	0.1	0	0	0	0	0	0	2,889
Southeast*	81.2	6.1	11.4	0	1.3	0	0	0	701
Florida*	54.3	28.6	0	0	17.1	0	0	0	574
South	60.0	2.1	3.4	23.8	7.4	3.3	0	0	984
Central	58.7	0	41.3	0	0	0	0	0	6,202
West	12.8	0	0	0	0	21.0	66.2	0	909
Mexico	0.5	0	0	1.2	0	44.8	37.7	15.8	406

* For the purposes of this table this region has been divided into two parts.

TABLE 3. Per Cent Occurrence of Forms of *A. striata* from Each Area.

Area	% form A	% form B	% form C	% form D	% group S	Total specimens
Northeast	40.1	6.8	19.1	0	34.0	2,885
Southeast**	46.4	35.3	15.3	0.2	2.8	569
Florida**	96.2	0.3	0.3	0	3.2*	312
South Central	15.1	20.5	1.0	45.1	18.3	590
North Central	7.8	13.8	28.4	28.7	21.3	3,640
West-Mexico	0	3.4	0	61.0	35.6	118

* These are *aurata-striata* intergrades (probably *striata* form A).
** For this table the southeastern region has been divided into two parts.

classed as intermediates between the forms or species. We have here an excellent case of very similar, sympatric populations with no apparent ecological segregation.

REGIONAL ACCOUNT OF THE SPECIES

The area under consideration in this paper, including Canada, the United States and Mexico, has been divided into regions, as indicated for the Regional Keys, in order to discuss and compare variation within and among species.

The relative abundance of each species within each region is shown in Table 2, and the relative abundance of each of the forms of *striata* is given in Table 3 and Figure 92. The regions in the latter are subdivided to give a more accurate indication of the relative frequency of the different forms. Unless otherwise stated, the discussions of *striata* below concern only females.

NORTHEAST

Species represented: *A. striata* A, B, C.

A. striata is the only species known to occur widely in this region, although other species have been reported in the literature, presumably erroneously, and occasional specimens of *gratiosa* or *persimilis* may occur along the southern borders of this region. The three forms of *striata* are sometimes difficult to distinguish, especially in this region, and therefore the percentage of group S (unplaced specimens) is comparatively large (Fig. 92).

In the southern part of the region, as far north as New Hampshire and Vermont, form A is distinct and easily separated from B and C, though extremely variable. The disc is seldom bracket-shaped but is characterized by a sharp to carinate posterior edge, at least medially, with the median portion coming to a distinct point. Its length is usually equal throughout and its

shape is a broad but well defined V (Fig. 60). The length of the disc and the size and regularity of the striae are variable as is the size of individual specimens. Nearly all specimens of form A are weakly rugose or finely roughened on the posterior vertical surface of the propodeum. Large, coarsely rugose specimens resembling form A from Florida (Fig. 59) are occasionally found as far north as Massachusetts, but they have the light green color of northern specimens. In Massachusetts [Revere, VII-28-92 (F. A. Eddy Coll'n) (22), 2 specimens; Needham, V-18-20 (F.X.W.) (22), 1 specimen] these large individuals contrast strikingly with other individuals of form A, but to the south they tend to intergrade with other form A variants and are less noticeable. In Maine and Canada nearly all specimens differ from the standard of form A in that the posterior edge of the disc is less sharply angulate, the shape of the disc is more variable, usually somewhat rounder, and the median V is often only weakly indicated.

In Canada and Maine, group s consists chiefly of individuals that have characteristics of all forms rather than resembling variants of any one form. In the rest of the northeastern region specimens of group s are mostly variations of form A that do not agree with the standard either because they lack the median V or the angulate edge of the disc or because the shape of the disc is unlike that of the standard or the usual variants of form A from this region. A few scattered unplaced specimens resemble form D and a few may be variations of B or C.

Form C is generally more common than B in the Northeast, especially to the north. Only in Pennsylvania is B more abundant. Specimens similar to the standards for forms B (Fig. 63) and C (Fig. 62) are present throughout the region, but because of modifications of the shape and distinctness of the posterior edge of the disc, complete intergradation occurs making the separation of the two forms difficult (Fig. 65). In Canada and Maine the two forms are more clearly separable, with fewer intergrades.

If form D is present in this region it is not common and cannot be recognized as distinct. An occasional specimen resembles form D, especially some small individuals of form B, but these are few even in New York State from which more than 900 specimens were examined.

The color of most specimens of all forms is a bright green, although yellow-green or dark green specimens are not uncommon and blue-green individuals are occasionally found. The scutal and metasomal punctation is variable in both sexes throughout the area. Many males can be segregated into the lettered forms, especially form A, but individual variation is great and numerous and complex combinations of characters can occur, adding to the confusion rather than clarifying the nature of the variation.

SOUTHEAST

Species present: *A. striata* A, B, C, *aurata, gratiosa, persimilis.*

In Florida three species occur throughout the state, *striata*, *gratiosa*, and *aurata*. In Georgia, *striata* A, B, and C occur throughout the state, form B being most common. *A. gratiosa* and *aurata* occur chiefly in the southern counties but are also found sporadically in the mountains of the north; *persimilis* is found in the northern part of the state. In the Carolinas, *persimilis* has been taken in the mountains to the west, *gratiosa* appears nearer the coast and the three forms of *striata* occur throughout. The one specimen of *aurata* seen from North Carolina lacked detailed locality data. In Virginia, *striata* A, B, and C occur throughout the state, and *persimilis* ranges along the western border as far as Maryland, apparently its northern limit in the east. *A. gratiosa* probably occurs in Virginia as it has been taken in nearby Maryland, but this appears to be its northern limit also. Except for the few *gratiosa* from Maryland, only *striata* has been found in that state.

A. striata. There is comparatively little variation within the three forms of *striata* in this region. Only form A is present in Florida (except for one female of form B from Gainesville and a male of form C simply labeled "Florida"). About 90% of the female specimens are large, dark green to blue-green and very coarsely sculptured, especially on the scutum and propodeum. The other 10% are less rugose and resemble *striata* A from other regions. The disc in both sexes is usually bracket-shaped with a sharply angulate or carinate posterior edge (Fig. 59), although the disc may become more V-shaped and develop a well defined but less sharply angulate posterior margin in some specimens. The posterior vertical propodeal surface varies from rugose to smooth in females (always rugose in males), and the punctures on the first metasomal tergum are variable but usually small and widely spaced. Small workerlike individuals are rare and always look similar to the larger, rough specimens. All but four of the males from Florida belong to the large, robust and coarsely sculptured form A. One of the four is form C, the other three, similar to males from outside Florida, cannot be classified as to form. Each differs from the others in the shape and size of the disc and in the type of scutal and metasomal punctures.

Throughout the rest of the southeastern region, form D as a distinct group is not found although B-D intermediates (Fig. 72) do occur. A few of the coarsely rugose Floridian representatives of form A range into Georgia but most specimens from Georgia and elsewhere in this region are similar to the standard of form A. Most such form A specimens are bright green in color although some are yellow-green. They differ from forms B and C throughout the region, without intergradation.

Form B is usually distinctive although intergrades with D and C are found

in both sexes. Most specimens of form B have a long, roundly V-shaped disc (Fig. 63) with the edge of the disc well defined. In Georgia, the disc may be slightly shorter and rounder than normal, resembling that of form D (Fig. 72), or less V-shaped in appearance, thus resembling form C (Fig. 65).

Form C is considerably more variable than either A or B. The shape of the disc varies from semicircular to U-shaped and grades into the V-shape of form B. The edge is smoothly rounded and shiny, with little differentiation between the disc and the vertical surfaces. A few small females throughout the area resemble *persimilis* but have the striae reaching or almost reaching the posterior margin of the disc. Both B and C are usually yellow-green in the southern part of the region and a yellow-green to bright green in Virginia, Maryland and the District of Columbia. The metasomal punctures in all forms are usually small, close, distinct and regularly spaced in both males and females although other punctation patterns may also occur. Most of the males can be placed as to form even though the size, shape and sculpturing of the disc is variable within any one form.

A. persimilis. There is little variation in *persimilis* in this region. Specimens are generally a light green to yellowish or coppery-green color and the disc (Fig. 64) and posterior vertical surface of the propodeum (Fig. 74) are similar to those of other specimens throughout the range. The pubescence, however, may be more golden in color than it is to the west. The species is not numerous and occurs chiefly in the western edge of the region. Intermediates between *persimilis* and small *striata* C may occasionally be found among the females.

A. gratiosa. This species is particularly abundant throughout Florida and probably Georgia but becomes sparse to the north. Specimens are usually dark green to deep blue in Florida but are generally a yellow-green to bright green in the rest of the region. This species shows little morphological variation except in Florida where the propodeal disc is often exceedingly short (Fig. 58) with the posterior edge of the disc more sharply angulate than elsewhere in the range. The characters of females in this species intergrade with those of *aurata* in Florida although most specimens can be distinguished by the key characters.

A. aurata. In Florida, the range of variation of *aurata* overlaps that of both *striata* A and *gratiosa*. In Georgia, however, the species seems to be distinct. Most female specimens look similar to *gratiosa* with a rather short, weakly bracket-shaped disc (Fig. 57), fine striae and a similar body size. The males are most similar to *striata* with short hair on the hind basitarsus and a narrowly emarginate fourth metasomal sternum. The variation in specimens from Florida mainly involves body color, and the size and sharpness of the posterior edge of the disc in both sexes. The few specimens seen from Georgia were all alike in coloring and characters of the propodeum.

North Central

Species present: *A. striata* A, B, C, D, *persimilis*.

In the northern part of this region (Michigan, northern Wisconsin and Minnesota) only *striata* is found, forms A, B, and C occurring to the east and B, C, and D to the west. In the east form A is the most abundant, in the west form D is most abundant, form C being more abundant than B throughout the region (Fig. 92). Further south, *persimilis* is also found, its greatest abundance in the western part of its range, particularly in Kansas, Iowa and Illinois. In the southern part of the region, *striata* C is more abundant than B, with form A decreasing in abundance and form D increasing from east to west. *A. persimilis*, though present, is less abundant than it is farther north.

Throughout this region where *persimilis* and *striata* C are common, intermediates between the females of the two species are found. In all areas, *striata* is more abundant than *persimilis*.

A. striata. In the North Central region there is a shift in the proportional abundance of forms from east to west. Form A is distinct from other forms in Ohio, Indiana, Illinois, Tennessee and Kentucky (Fig. 56). There seem to be several variants of this form present, so that the form could be easily divided into a number of subtypes based chiefly on shape of the disc and robustness of the bee. To the north, in Michigan, Minnesota and Wisconsin, the edge of the disc becomes less sharp than in the standard and eastern specimens, and the shape of the disc is variable so that none of the subtypes are well defined or distinctive. One specimen similar to those from Florida (Fig. 59) was found in Iowa [Ames, XI-1-59 (D. Easterman) (18)]. It contrasts strongly with the other specimens, the usual form A being smaller, yellower, less robust and less coarsely rugose. Form A becomes less abundant to the west and grades into form D, although a few rather distinct individuals of form A occur in Nebraska, Kansas and Colorado. They are apparently absent in Oklahoma, Arkansas and Missouri although the form may be represented as intergrade types in these areas exhibiting an abrupt, but not sharp, posterior discal edge, with or without a medial V.

Form B usually is distinct, most specimens agreeing well with the standard (Fig. 63). The proportional abundance, however, decreases sharply to the west and the form is entirely absent in Colorado. Variants from the standard grade into both C and D. Form B-C intergrades (Fig. 65) are found frequently to the north in Michigan and Minnesota, and Ohio to Illinois and possess an elongate disc grading from V- to U-shaped, usually with a distinct but rounded edge. Form B-D intergrades (Fig. 72) are found more frequently to the west in Illinois, Iowa and Kansas where the disc becomes shorter and more semicircular. Form C-D intergrades are found throughout the Central region. In Kansas, four nests were found containing both B and

D individuals, but in no case did any of the specimens agree with the standards. Also, there were four nests containing B-C intergrades, two of the nests also containing at least one specimen distinctly of form B.

Form C is variable and poorly defined in the eastern part of the North Central region but numerous and distinctive to the north and west. There are a number of different subtypes represented, with specimens resembling the standard (Fig. 62) found chiefly in Illinois, although they also occur in varying proportions elsewhere throughout the region. In Ohio, Tennessee, and Indiana there are many individuals resembling B-C intermediates (Fig. 65), but in Indiana and lower Wisconsin the majority of the individuals of this form are small and intergrade with *persimilis* (Fig. 28). In Kansas, Missouri, Arkansas and Oklahoma about 50% of the form C group consists of these small *persimilis*-like intermediates. These small specimens also occur sparsely in Minnesota, Iowa and Nebraska. In Michigan, South Dakota and Colorado there are some individuals with *persimilis*-like discs but the specimens are large and would not be confused with *persimilis*, a smaller species. These larger subtypes also occur in Kansas, Nebraska and Missouri. Other variations from the standard also occur throughout the North Central region (Fig. 61); sometimes they represent intergrades with forms B or D.

Form D is not abundant nor distinct as a form in the eastern and northern states, although D-like specimens are occasionally found. It intergrades chiefly with form A in Michigan and Wisconsin, where the disc is weakly bracket-shaped and the edge of the disc may become sharper than normal, with a weakly developed medial V. This form intergrades with form B in South Dakota, where the disc becomes more V-shaped and longer than the standard. Form D individuals are proportionally more abundant than other forms in the Great Plains states and although variable, the majority are similar to the standard of form D (Fig. 71). Small workerlike individuals are present, some resembling the larger individuals, others being intermediate between the small form C and *persimilis*. Biological data are scarce but six nests of this form were found in Kansas, all containing large and rather standard individuals, without worker forms. Four other nests contained both distinct B and D individuals.

A. persimilis. There is little variation in size or structure in *persimilis* throughout this region, although specimens tend to be somewhat greener (less yellowish) and the pubescence generally whiter than in the east. Throughout the region the disc of the propodeum is as in Fig. 64.

A. gratiosa. *A. gratiosa* is not known in this region, although it may be found along the southeastern borders. It will look similar to *striata* A but with finer, closer striae (Fig. 58) and a rough or granular posterior vertical propodeal surface (Fig. 76). One specimen has been seen from eastern Tennessee.

SOUTH CENTRAL

Species represented: *A. striata* A, B, D, *persimilis*, *gratiosa*, *neglectula*, *aurata*, *bracteata*.

In the western part of this region, the southwestern portion of Texas along the Mexican border as far east as Val Verde Co. and north into the Davis Mountains, *neglectula* and occasionally *striata* have been found. In the southern part of Texas, east of the Edwards Plateau, both *bracteata* and *aurata* occur, *bracteata* occurring as far north as Dallas Co., and *aurata* into Nacogdoches Co. *A. bracteata* has also been taken along the Rio Grande west to Val Verde Co., where it meets but probably does not overlap the range of *neglectula*.

A. striata, *gratiosa* and *persimilis* also occur to the east of the Edwards Plateau, *gratiosa* coming from the east and occurring from south of Galveston to Nacogdoches, *persimilis* going only as far south as Nacogdoches, and *striata* ranging south to near Corpus Christi. *A. striata* is the only species on the Edwards Plateau, and although there seems to be a gap between the eastern populations and those of New Mexico and southwestern Texas, all the bees of this species look similar to one another. In Louisiana, Mississippi and Alabama, *gratiosa* and probably *aurata* occur to the south, *persimilis* is rare, and *striata* occurs commonly throughout.

A. striata. In the eastern part of this region, form A looks similar to its standard (Fig. 60) but becomes less distinct to the west and all but disappears as a distinct form, grading into form D. Thus, the posterior edge of the disc becomes less sharply defined than in the standard although abruptly rounded, and the disc becomes less angular and the bracket-shape less well defined.

In the eastern part of the region, most specimens of form B are large and agree well with the standard. Toward the west the characters of form B grade into those of form D. The posterior edge of the disc remains abruptly rounded but the length of the disc decreases and the outline gradually changes from the broad V typical of form B (Fig. 63) to the semicircular shape of D (Fig. 71). Form B also decreases in proportional frequency although a few specimens similar to the standard are found in eastern Texas.

In form D the length of the striae and angulation of the posterior margin of the disc as well as the shape of the disc are variable but in general resemble that in Figure 71. Form C is not distinct in this region, although occasional specimens may show some resemblances to it.

In Louisiana and Texas, a few small *persimilis*-like individuals are present that would belong to form C in other parts of the range, but are probably worker individuals of form D in this region. These are always distinct *striata*, however, and except for size do not intergrade with *persimilis*. To the west the percentage of form D increases.

Throughout the region both color and punctation of females are variable. Males are individually variable with only a few specimens distinctive enough to be placed in one form or another; none of the males in this region seem to intergrade with any other species.

A. persimilis. *A. persimilis* occurs very sparsely in this region and appears to differ little from those elsewhere in the range (Fig. 64). Most specimens are a yellow-green or coppery green in color. This species does not intergrade with *striata* c or d in this region, although there are small individuals of *striata* in Texas and Louisiana.

A. gratiosa. Only a few specimens of *gratiosa* have been seen from this area. All are similar, usually bright green or yellow-green in color. The propodeal disc is usually about equal in length to the metanotum, sharply defined but rarely carinate. Some females may be confused with females of *aurata* in this region.

A. aurata. Females of this species have been taken from throughout southeastern Texas and, although variable in disc characteristics, can be distinguished from other species by the key characters. The females are most similar to *gratiosa*. No males have been seen, and no specimens of either sex have been taken between southeastern Alabama and Texas, probably due to lack of collecting in this area.

A. neglectula. This species is a dark green, roughly sculptured species (Figs. 70, 75) with all specimens similar to one another in this region. Although *striata* and *bracteata* have also been taken in the same area, it is probable that the three species occur in different habitats.

A. bracteata. This species is similar to the small *striata* c-*persimilis* intermediate in size and in appearance of the propodeal disc (Fig. 66). Both of these characters show considerable variation, but the thoracic sculpturing (Fig. 78) is distinctive and unvarying and serves to separate this species from *persimilis*, *aurata* and *striata* in Texas.

West

Species represented: *pomoniella*, *neglectula*, *striata* b, d.

The only species occurring in California, Utah and Nevada is *pomoniella*. *A. pomoniella* enters Utah only in the extreme southwestern corner, in Washington Co. In Arizona, both *neglectula* and *pomoniella* are found, *pomoniella* to the west and *neglectula* to the east, with their ranges broadly overlapping in the center of the state. In New Mexico, *striata* comes in from the northeast and ranges southward to the Mexican border through the eastern half of the state. *A. neglectula* ranges across the southern half of the state.

A. striata. Most of the individuals of *striata* are small (6 mm), about the size of large *persimilis.* The scutum is rather finely punctured or finely rugose, and the shape of the disc is somewhat variable, but the striae in all cases fill the discal area and reach the distinct posterior edge. The posterior surface of the propodeum is finely granular or weakly roughened, shiny or dull, and the color of the body varies from dark green to blue-green. Most *striata* belong to form D in this region, although an occasional form B is found. Individuals weakly A-like and intergrades between B and D are also occasionally found.

A. neglectula. There is little overall variation in this species except that the propodeal area varies in the degree of roughness of the posterior and lateral vertical surfaces. The smoother individuals superficially resemble *pomoniella* in Arizona or *striata* in New Mexico, although there is usually little difficulty in distinguishing the species, and the number of specimens showing this similarity is few.

A. pomoniella. There is little variation in size, color or morphological characters in specimens from California, Nevada and Utah, but in Arizona, specimens are smaller and more variable in the propodeal characters and in color. *A. pomoniella* is, however, distinctive throughout the area and does not intergrade with *neglectula* which it overlaps in Arizona.

Mexico

Species present: *A. neglectula*, *pomoniella*, *bracteata*, *edentata.* Other species found only in the Neotropical region and belonging to *Pereirapis* are not included here.

Throughout the central part of Mexico from the northern border into Central America, *A. neglectula* is the most common of the species considered in this paper. It occurs throughout Mexico except along the coasts. Both *edentata* and *bracteata* are also found in the central area but occur only sparsely in the eastern part.

In Baja California and along the western coastal area, *pomoniella* is found, and along some beaches of the west coast, *maritima*, a subspecies of *neglectula* is found. Apparently both *pomoniella* and *neglectula* occur together south of Morelos although they have not been collected simultaneously from any one area. In Chiapas and Yucatan, only *pomoniella* has been collected.

A. neglectula. This species shows little variation in Mexico, except for Pacific Coast populations placed in the subspecies *maritima.* Occasional female specimens are dull rather than shiny, with the body surfaces minutely reticulated, especially on head and thorax. The blue patches on the frontal areas are rarely conspicuous on Mexican specimens, and occasional specimens with unusually smooth propodeal areas may look similar to *pomoniella.*

Many of the specimens of the subspecies *maritima* are from the same population and therefore show little morphological variation among themselves.

A. pomoniella. This species is rather variable in size, color and sculpturing, especially in southern Mexico. Specimens from Baja California and Sonora are large and much like those from California, but those from further south are small, often with paler brown and darker green coloration. The range of *pomoniella* overlaps that of *neglectula* in Guerrero and Oaxaca, and females from these areas may intergrade morphologically.

A. bracteata. Only a few specimens of this species have been taken in Mexico so that the nature of the variation has not been determined. The specimens seen are like those from Texas and are easily differentiated by the key characters from other species of this region discussed in this paper.

A. edentata. This species is somewhat variable in both color and sculpturing, but until more specimens can be seen, the extent of the variation cannot be described. It is distinguished from other Mexican species discussed here by its smaller size, smooth sculpturing (Fig. 79), convex face and other key characters.

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